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# APPRAISAL OF AIR POLLUTION IN TENNESSEE. REPORT OF A COOPERATIVE SURVEY BY THE U.S. PUBLIC HEALTH SERVICE, AND THE STATE OF TENNESSEE DEPARTMENT OF PUBLIC HEALTH, DECEMBER 1956-JULY 1957

Paul A. Kenline

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

September 1967

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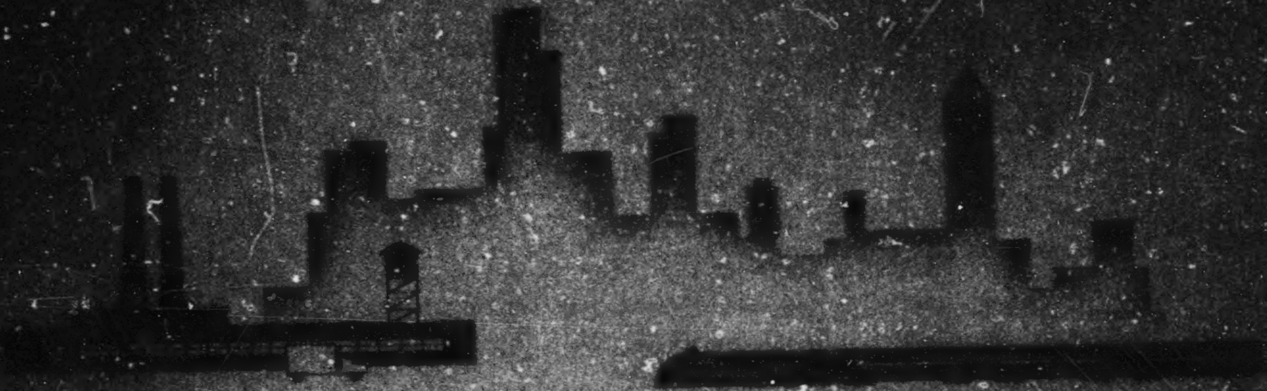

# APPRAISAL OF AIR POLLUTION IN TENNESSEE

A JOINT REPORT WITH THE
STATE OF TENNESSEE DEPARTMENT OF PUBLIC HEALTH

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
September 1957

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**REPORT OF A COOPERATIVE SURVEY BY THE**

**U. S. PUBLIC HEALTH SERVICE AND THE**

**STATE OF TENNESSEE DEPARTMENT OF PUBLIC HEALTH**

**DECEMBER 1956-JULY 1957**

**Paul A. Kenline, Senior Assistant Sanitary Engineer**

**State and Community Services Section**
**Community Air Pollution Program**
**Public Health Service**

**U.S. Department of Health, Education, and Welfare**
**Public Health Service**

**Robert A. Taft Sanitary Engineering Center**
**Cincinnati, Ohio**
**September 1957**

I

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Department of Conservation

Department of Employment Security

Department of Finance and Taxation

Department of Highways and Public Works

Department of Public Health

And finally, to members of the staff of the Robert A. Taft Sanitary Engineering Center of the Public Health Service.

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# SUMMARY

An appraisal of factors relative to air pollution was made in Tennessee by the Public Health Service at the request of, and in cooperation with, the State of Tennessee Department of Public Health, for purposes of determining the status of air pollution in the State and the need for activity by the State government in solving air pollution problems. These purposes were accomplished through interpretation of information obtained by review of existing published and unpublished material; by interviewing local health officers, city officials, and others; by personal observation; and by questionnaires. Information was secured which would indicate the occurrence of air pollution problems, the awareness of local agencies of the problems, the general nature of local control programs, the presence of potential pollution problems and adverse pollution factors, and the need for future activity to insure adequate protection of the vital air resources of the State.

Air pollution problems were found to exist in many areas of the State. Forty-two of the 67 local health departments (63 percent) reported the emission of objectionable amounts of pollutants within their areas of jurisdiction and nearly one-fifth consider that they have a major problem. These problems range in nature from localized situations of limited severity to community-wide problems of major significance. While air pollution problems are more closely related to urban areas, many of the more rural areas of the State reported undesirable pollution sources and effects. Of the 26 counties with over 30,000 population (generally containing a city of over 10,000 population), 92 percent (24 counties) reported the emission of objectionable amounts of pollutants, while three counties (12 percent) considered their problems of major significance. In the more rural areas, 18 of 41 local health departments (44 percent) reported the emission of objectionable amounts of pollutants, and nine (22 percent) considered their problems of major significance. Of 67 local health departments, 38 (57 percent) reported air pollution as the cause of discomfort or inconvenience to residents; 13 (19 percent) reported damage to property, and seven (11 percent) reported injury to vegetation or animal life. In 31 (46 percent) of these local health department jurisdictions, people have filed formal complaints with local officials concerning air pollution.

With a growing trend toward urbanization and an expected increase of 40 to 65 percent in the State's total population by the year 2000, all or most of which will occur in the larger urban areas, an increase in the number and severity of air pollution problems can be anticipated because of increased emission of pollutants associated with a variety of man's activities.

Combustion of soft coal in residences, commercial establishments, public buildings, and industry contributes substantially to the air pollution problem in many cities, particularly in east and middle Tennessee. It contributes largely to community-wide air pollution in Nashville, Knoxville, Bristol, Kingsport, and Chattanooga. Combustion of coal also creates a local nuisance-type problem in many other areas of the State. The problem is largely seasonal, being of most concern in the winter (heating season). Use of soft coal, however, is decreasing except for generation of electricity and, therefore, the problems associated with its use are also decreasing. Pollution emissions from combustion of coal are at a markedly lower level now than 10 or 20 years ago and probably will continue to decrease.

The use of gas, fuel oil, gasoline, and diesel fuel, although not ordinarily

associated with the emission of visible smoke and fly-ash, is responsible for emission of large quantities of pollutants to the atmosphere. Use of these fuels in homes, commerce, industry and transportation is increasing at a rate commensurate with the rising population and expanding industrialization of the State. Such fuel usage ordinarily is of no air pollution concern in rural areas and smaller cities, but it must be given due consideration in the few larger urbanized areas of the State where area-wide type pollution problems exist or are developing.

Industry contributes a great variety and quantity of pollutants to the atmosphere. These pollution emissions. like those from fuel combustion, are largely but not exclusively concentrated in the urban areas. Unlike pollution from the use of coal, industrial emissions to the atmosphere are increasing with the increasing industrialization of the State. Widely reported or particularly outstanding emission sources include the following industries: chemical (phosphate, and rayon production especially), food, primary metals (especially electrometallurgical and foundry operations), lumber, paper (particularly odors from pulp mills), stone, clay and glass (particularly cement plants), mining, and cotton ginning.

Refuse burning on open dumps with the usually resulting smoke and odor problem was reported as a major air pollution offender, particularly in the smaller cities.

The ability of the atmosphere to disperse pollutants is determined by topographically influenced climatological conditions. Generally speaking, these conditions appear favorable to the dispersion of pollutants in west Tennessee, moderately so in middle Tennessee (the Nashville basin), and least favorable in east Tennessee. East Tennessee, with its mountain and valley topography and associated poor air circulation, warrants particular concern. This area of the state also has the greatest population and industrial concentration, is the largest soft coal user, and shows the greatest potential for population and industrial growth, because of excellent water, mineral and fuel resources.

Only four cities and a handful of other organizations have made measurements of air pollutants. Technical information is lacking on the amount and nature of pollutants, from which detailed information relative to air pollution levels might be drawn. Such information is useful and necessary in planning an effective air pollution program.

Eight areas in the State (Sumner County, Nashville, Dyer County, Chattanooga, Hamilton County, Cleveland, Wilson County, and Henderson County) reported the existence of air pollution problems in which the pollution sources were located in another jurisdiction. Some means of providing for an equitable solution to these problems of interjurisdictional nature should be provided.

Seven cities in the State have air pollution or smoke control ordinances. These are Chattanooga, Dyersburg, Jackson, Kingsport, Knoxville, Memphis and Nashville. Of these, only four (Chattanooga, Kingsport, Knoxville and Nashville) have control programs, none of which appear to be of sufficient magnitude to deal effectively with their problems.

It is concluded that air pollution problems exist in many areas of the State; that these problems arise from many sources and cause nuisance conditions, damage to property, economic loss, and injury to vegetation and animal life; that these problems cannot be handled effectively by existing local activities in most instances; and that there is need for additional activity in the air pollution field at both the State and local levels. The local governments, with reason, look to the State for technical assistance and guidance in meeting their complex air pollution problems.

# RECOMMENDATIONS

On the basis of the findings of this survey and present knowledge of the growing problem of air pollution, it is recommended that the State:

1. Recognize air pollution as a matter of State concern.
2. Encourage local agencies to handle air pollution problems to the greatest extent that their resources permit.
3. Enact appropriate legislation to develop a State air pollution program and preserve the State's air resources. In this connection, the following principles are suggested for review and consideration:
    - (a) State legislation should be designed to permit orderly development of the program of the State agency designated to carry out its provisions. The legislation must provide the basis for establishing the organizational unit in the State agency and for recruiting competent personnel to staff this unit.
    - (b) The legislation should provide the basis upon which the State agency can plan a comprehensive program, taking into account the varying requirements of the different areas in the State.
    - (c) The State agency should have the authority to provide the necessary services in those areas of the State where there is no local staff but where there is need for attention.
    - (d) The State agency should have the authority to engage in research programs directed toward the solution of the air pollution problems occurring in the State.
    - (e) The State agency should be authorized to collect and disseminate information relating to air pollution, its prevention and control.
    - (f) The State agency should be authorized to provide technical assistance and cooperation to local and regional control programs.
    - (g) The State agency should have the authority to conduct studies and investigations relating to air pollution as it may deem advisable and necessary, or as specifically requested by local and regional control organizations.
    - (h) The State legislation should make clear that all causes and effects are included within the areas of responsibility of the State agency; in addition to health effects these would include the effects on plant and animal life, on visibility as it effects air and surface transportation, and on structural materials and surfaces.
4. Consider the need for enabling legislation to provide for jurisdictional areas different from existing political jurisdictions for air pollution control purposes.
5. Designate an agency to represent the State in interstate and Federal air pollution matters.

# INTRODUCTION

## AUTHORITY FOR STUDY

Public Law 159, 84th Congress, provides in part that the Surgeon General of the Public Health Service may, upon request of any state or local government air pollution control agency, make surveys of its air pollution problems with a view to recommending solutions for such problems. This study is the result of a request by the State of Tennessee, Department of Public Health for U. S. Public Health Service assistance in conducting an evaluation of the air pollution problem of the State.

## PURPOSE OF STUDY

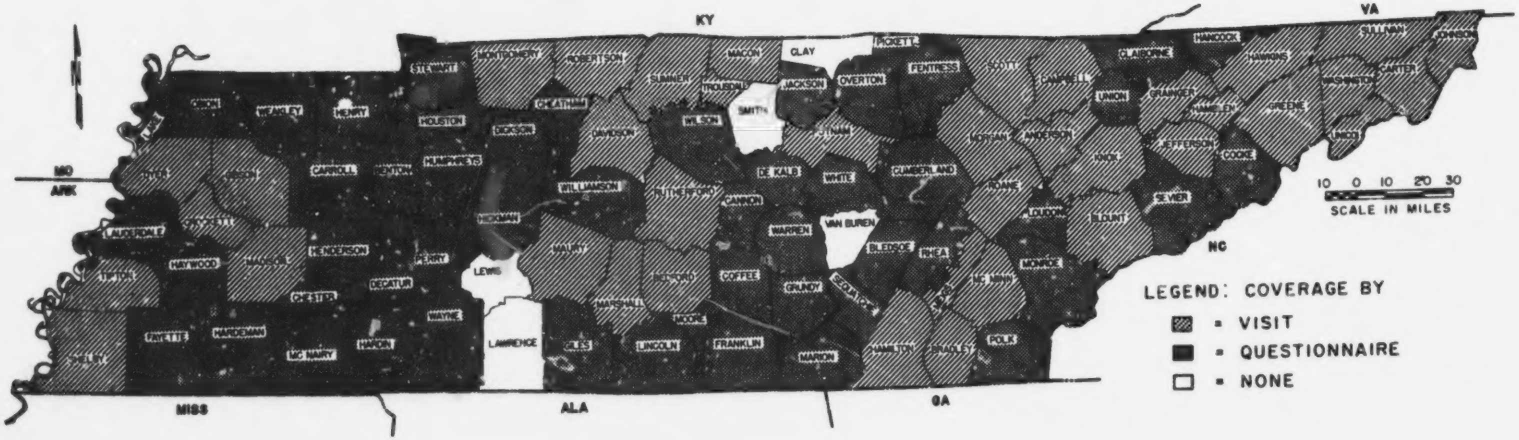
As Communities grow in population and as industrial activity increases in amount and complexity, air pollution and the need for appropriate control measures will undoubtedly grow. It is the purpose of this study to describe characteristics of the State as they relate to its air resources; to assess the present and potential status of air pollution, to review current local problems and (briefly) local control efforts; and, on the basis of this information, to recommend desirable future activities needed, particularly at the State level, to maintain a healthful and comfortable air environment.

## METHODOLOGY USED IN THE STUDY

To describe characteristics of the State as they relate to its air resources, information was compiled from existing data on population, topography, climatology, fuel usage, transportation, refuse disposal, and industrial activity. Information on local air pollution problems and control efforts was obtained through questionnaires, interviews with informed individuals--both public officials and private citizens--direct observations, and review of existing information.

Local government in Tennessee is concentrated in the counties, of which there are 95. There are also 261 incorporated cities. Of these, there are 16 with a population of over 10,000 and 114 with a population of less than 1,000. Of the 95 counties, 50 are served by full-time health departments, 39 are served by 16 full-time district health departments (covering from two to four counties), three are served by part-time health departments, and three are not served by a health department. Since all initial contacts were made with local health departments, five counties are excluded from survey coverage although one of the part-time departments was visited. The excluded counties are Clay, Lawrence, Lewis, Smith, and Van Buren. These counties contain 1.9 percent of the State's population and 1.0 percent of its industrial employment.

Visits were made to all cities with over 10,000 population, to county seats of all counties with over 30,000 population, and to several small cities. These communities account for 82 percent of the State's urban population. Visits were made to 26 local (county and district) health departments, which serve 71 percent of the State's entire population. Survey coverage by county is shown in Figure 1. In each community visited, the first interview was with the local director of health. Thereafter, no set pattern was followed; information was obtained where possible. Sources consulted included city managers, mayors, city engineers, U. S. Weather Bureau personnel, air pollution or smoke control bureaus, police departments, building departments, fire departments, chambers of commerce, fuel dealers, newspaper offices, city health departments,


KY
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MONTGOMERY
ROBERTSON
SUMNER
MACON
CLAY
PICKETT
FENTRESS
SCOTT
CAMPBELL
CLAIBORNE
HANCOCK
HAWKINS
SULLIVAN
JOHNSON
OBION
WEAKLEY
HENRY
HOUSTON
CHEATHAM
DICKSON
TROUSDALE
JACKSON
OVERTON
SMITH
WILSON
DAVIDSON
PUTNAM
MORGAN
ANDERSON
UNION
GRAINGER
HAMBLEN
GREENE
WASHINGTON
CARTER
UNICOI
LAKE
DYER
GIBSON
CARROLL
BENTON
HUMPHREYS
WILLIAMSON
RUTHERFORD
DE KALB
WHITE
CUMBERLAND
ROANE
KNOX
JEFFERSON
COCKE
LAUDERDALE
CROCKETT
HAYWOOD
MADISON
HENDERSON
HICKMAN
CANNON
WARREN
VAN BUREN
BLEDSOE
RHEA
LOUDON
BLOUNT
SEVIER
TIPTON
CHESTER
DECATUR
PERRY
MAURY
LEWIS
BEDFORD
COFFEE
GRUNDY
SEQUATCHIE
MEIGS
MC MINN
MONROE
SHELBY
FAYETTE
HARDEMAN
MC NAIRY
HARDIN
WAYNE
LAWRENCE
GILES
MARSHALL
MOORE
LINCOLN
FRANKLIN
MARION
HAMILTON
BRADLEY
POLK
10 0 10 20 30
SCALE IN MILES
LEGEND: COVERAGE BY
▨ = VISIT
■ = QUESTIONNAIRE
☐ = NONE

STATE COVERAGE FOR SURVEY
FIGURE I

universities, regional planning commission offices, and private citizens.

To obtain information relative to air pollution problems in areas not visited, a questionnaire (Appendix A) was prepared and sent to local health departments. These questionnaires were designed to elicit the opinions of local officials relative to existence of air pollution problems, of sources and effects, significance of problems, and any local activity in the field. Questionnaires were sent to 41 health departments and replies were received from all of them.

The Public Health Service engineer spent seven months, from December 1956 to July 1957 gathering, evaluating and preparing information for this report.

## GENERAL DISCUSSION OF COMMUNITY AIR POLLUTION

It is difficult to define "community air pollution" in words acceptable to everyone. Some state that it is the addition of any foreign matter to "pure air;" this is somewhat severe and vague. One of the most recent definitions, used by the Federal Ad Hoc Interdepartmental Committee on Community Air Pollution, is, in part, as follows:

> Community air pollution is the presence in the ambient atmosphere of substances put there by the activities of man in concentrations sufficient to interfere directly or indirectly with his comfort, safety or health, or with the full use and enjoyment of his property.

For an air pollution problem to exist, three factors must be present: a source of pollutants, a susceptible population or other receptor, and a means of transport between the two (a mechanism which is controlled by topography and weather).

Determination of the existence of air pollution problems is not always based solely on known or suspected adverse effects on health, comfort, safety, or economics; public opinion is often the criterion. Nevertheless, it is the responsibility of the official agencies to point out unsatisfactory conditions, actual or potential, when such are not obvious to the public (for example, the presence of nuclear radiations), so that suitable community action will develop.

Exact appraisal of the atmospheric environment to determine whether air pollution exists is difficult, since no fully satisfactory index or criterion has yet been established. Community air pollution arises from many of the activities of man. Consequently, such factors as population density, industrial activity, modes of transportation, fuel usage practices, waste disposal practices, and other human activities individually or collectively play important roles. In addition, such natural features as meteorology and topography are important since they can strongly effect the accumulation of air-borne pollutants, possibly increasing their undesirable effects.

Today, air pollution is undoubtedly one of the most complex problems facing the environmental hygienist. Only recently has he begun extensive development of the skill and equipment necessary to measure the effects on man and to measure the microquantities of contaminants in the atmosphere. Along with this development, the attitude of the public in many localities has changed from one of apathy to one of concern.

Air pollution is a potential problem in all industrialized and urbanized areas. As concentrations of population becomes greater, the industrial, transportation, and waste disposal requirements become greater and pollution levels can be expected to rise. It is now realized in many regions of the United States that man must take further steps to safeguard his vital air resources. A result has been the initiation of prevention and control programs ranging in magnitude from the multimillion dollar activity in Los Angeles County to part-time, one-man activities in a number of small towns. In an attempt to define the nature and magnitude of their problem, many communities and States throughout the country are conducting studies. In some instances, these studies are highly detailed, and in others, they are general evaluations such as this statewide appraisal.

Pollution control programs have met with varying degrees of success. Some, as in Pittsburgh and St. Louis, have accomplished dramatic improvements in the cleanliness of the air. Generally speaking, fairly successful programs are proceeding on the basis of existing knowledge, although greater success and understanding, particularly in some areas, must await the results of further research. Technically, nearly all sources of pollution can be controlled; some in an entirely satisfactory manner and others to only limited satisfaction. Further research and development will continue to improve our ability to limit the discharge of pollutants to the air and to reduce the cost of doing so.

# FINDINGS

## POPULATION

The 1956 population of Tennessee is estimated at 3,541,833, an increase of 7.6 percent from the 1950 census.[1] Estimates of the future population of the State[2] indicate a population of 4 million by 1973 and somewhat larger than 4.5 million by the year 2000, a substantial growth.

The 1950 census[3] places the rural population at 1,839,116 and the urban population at 1,452,602. Thus, with 55.9 percent of the State's population living in rural areas (cf. the over-all U.S. figure of 36 percent), the State remains predominantly rural. Yet Tennessee has shown a consistent and generally increasing rate of urbanization except during the period following the Civil War and during the depression of the thirties. Thus, Tennessee is in transition from a rural to an urban complexion. This is indicated also by the fact that the sparsely populated, more rural counties are showing a loss in population, while the more densely populated urban counties are gaining. Between the 1940 and 1950 census, 42 of Tennessee's 95 counties had a decrease in population, only one of which had a population greater than 30,000. Of the 43 counties with less than 20,000 population per county, 29 had a loss in population (Table 1). As pointed out by the Tennessee State Planning Commission,[4] "Major war-effected changes in the economy of the South are found in . . . the concentration of population in urban areas." Figures 2 through 5 show pertinent population statistics, indicating past growth, present distribution, and anticipated future growth. Table 2 shows the distribution of population in 1950. Four places in the State have 100,000 or more population. This is a relatively high number for a southern State and again indicates a growing degree of urbanization.

It is noteworthy that there are no cities in the 50,000 to 100,000 population range. The four largest cities are Chattanooga, Knoxville, Memphis and Nashville. Their population and land areas are given in Table 3.

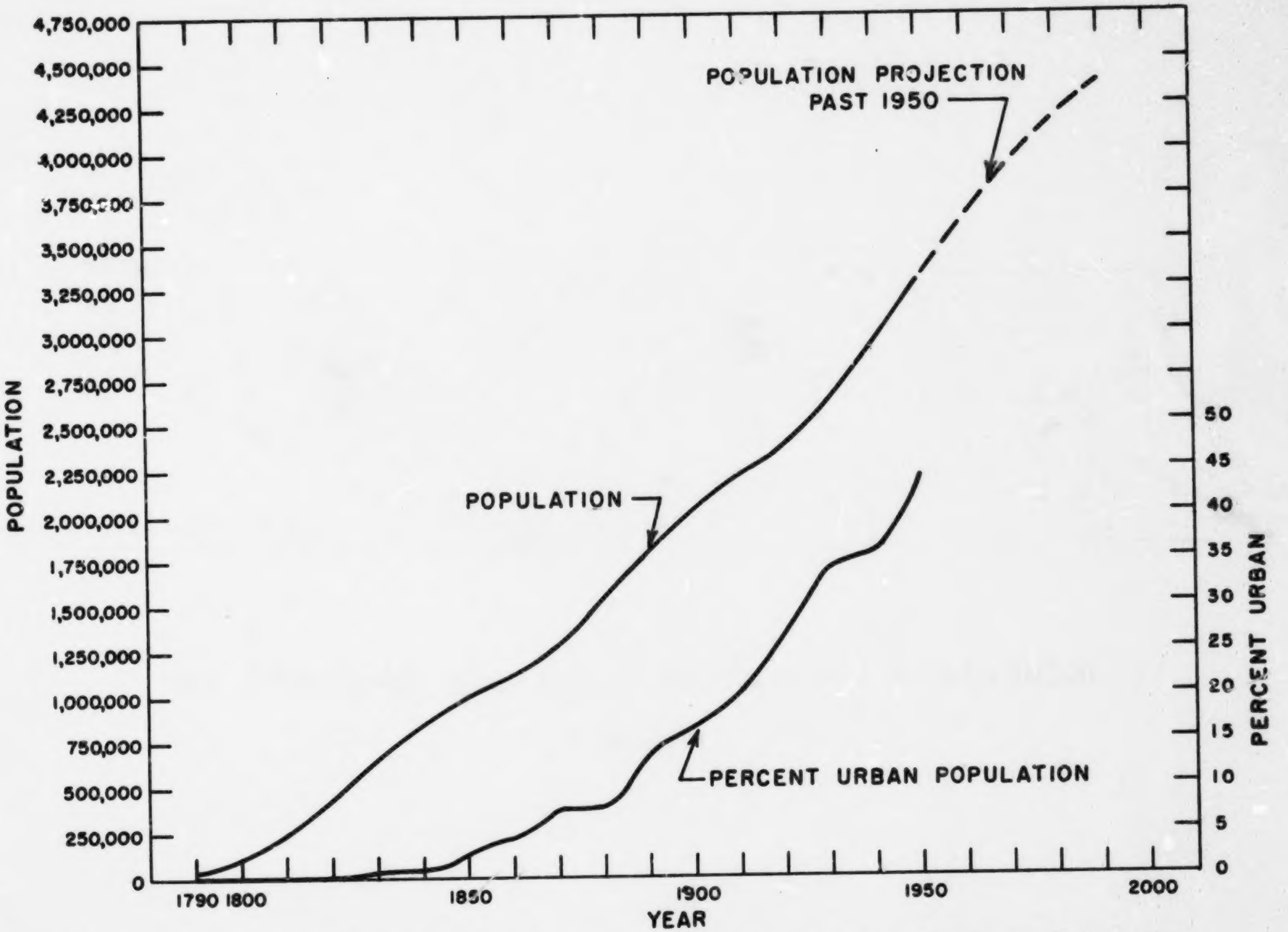
This population picture reveals the significant facts that the State is growing at a consistent though not remarkable rate and that the State is becoming more urbanized. Generally speaking, the eastern section of the State is expected to show the greatest increase in population.

The concentration of population in urban areas results in the creation of greater industrial and distribution centers. As communities increase in population and as industrial activity increases,

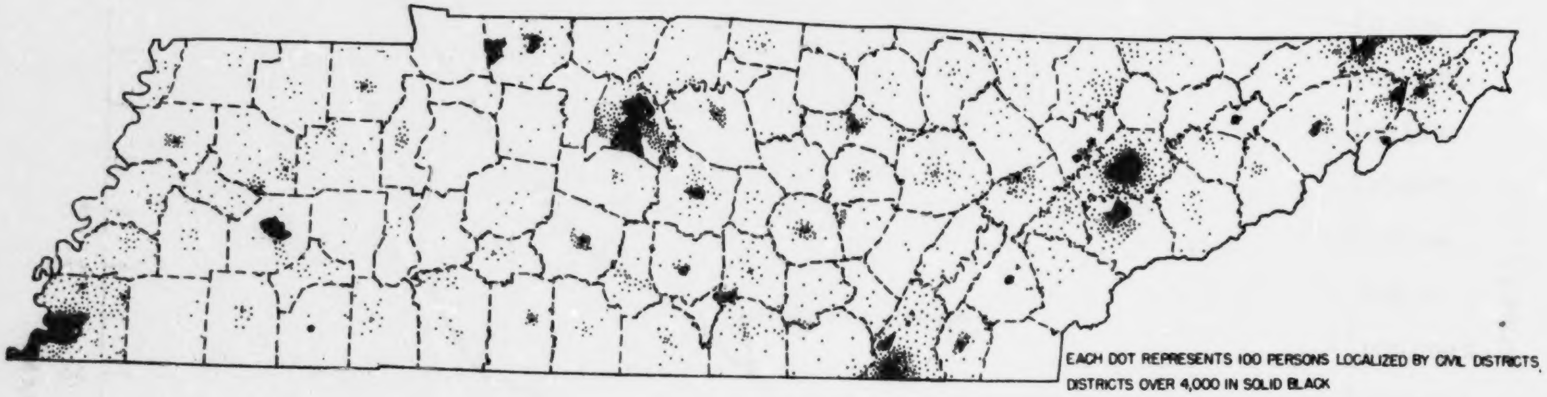
TABLE 1

CHANGE IN POPULATION OF COUNTIES, 1940-1950[3]

| POPULATION OF COUNTY | NUMBER OF COUNTIES IN STATE (1950) | NUMBER SHOWING DECREASE IN POPULATION 1940-50 | PERCENT SHOWING DECREASE IN POPULATION 1940-50 |
|---|---|---|---|
| 50,000 AND UP | 11 | 0 | 0 |
| 30,000 - 50,000 | 13 | 1 | 7.7 |
| 20,000 - 30,000 | 28 | 12 | 42.9 |
| 10,000 - 20,000 | 26 | 16 | 61.5 |
| UNDER 10,000 | 17 | 13 | 76.5 |
| STATE TOTAL | 95 | 42 | 44.2 |

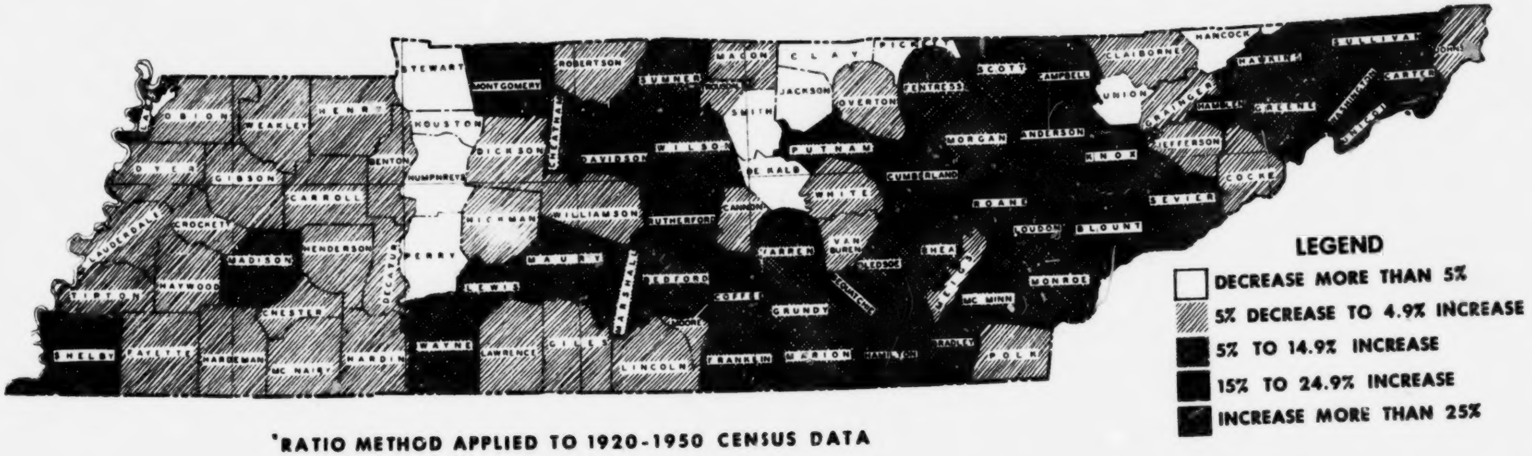


POPULATION GROWTH AND PERCENT URBAN POPULATION (3)
FIGURE 2


EACH DOT REPRESENTS 100 PERSONS LOCALIZED BY CIVIL DISTRICTS,
DISTRICTS OVER 4,000 IN SOLID BLACK

INCREASE IN POPULATION, TENNESSEE, 1940-1950 (3)

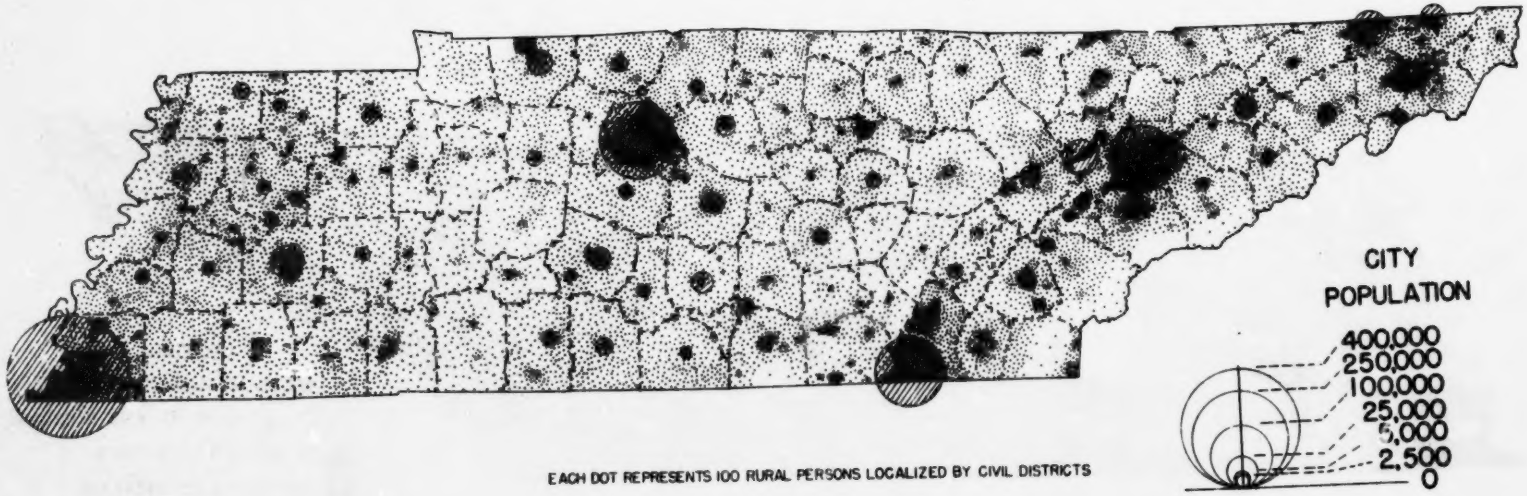
FIGURE 3


LEGEND
DECREASE MORE THAN 5%
5% DECREASE TO 4.9% INCREASE
5% TO 14.9% INCREASE
15% TO 24.9% INCREASE
INCREASE MORE THAN 25%
OBION
WEAKLEY
HENRY
DYER
GIBSON
CARROLL
BENTON
LAUDERDALE
CROCKETT
MADISON
HENDERSON
TIPTON
HAYWOOD
CHESTER
DECATUR
SHELBY
FAYETTE
HARDEMAN
MC NAIRY
HARDIN
STEWART
HOUSTON
HUMPHREYS
PERRY
MONTGOMERY
DICKSON
HICKMAN
LEWIS
WAYNE
ROBERTSON
CHEATHAM
DAVIDSON
WILLIAMSON
MAURY
LAWRENCE
GILES
SUMNER
WILSON
RUTHERFORD
MARSHALL
BEDFORD
MOORE
LINCOLN
MACON
TROUSDALE
SMITH
CLAY
JACKSON
DE KALB
CANNON
COFFEE
FRANKLIN
PICKETT
OVERTON
PUTNAM
WHITE
WARREN
VAN BUREN
GRUNDY
MARION
FENTRESS
CUMBERLAND
BLEDSOE
SEQUATCHIE
HAMILTON
SCOTT
MORGAN
RHEA
MEIGS
MC MINN
BRADLEY
CAMPBELL
ANDERSON
ROANE
LOUDON
MONROE
POLK
CLAIBORNE
UNION
KNOX
BLOUNT
HANCOCK
GRAINGER
JEFFERSON
SEVIER
HAMBLEN
HAWKINS
GREENE
COCKE
SULLIVAN
WASHINGTON
CARTER
UNICOI
JOHNSON

*RATIO METHOD APPLIED TO 1920-1950 CENSUS DATA

1965 POPULATION PROJECTIONS: PERCENT CHANGE FROM 1950 CENSUS (5)

FIGURE 4


CITY
POPULATION
400,000
250,000
100,000
25,000
5,000
2,500
0

EACH DOT REPRESENTS 100 RURAL PERSONS LOCALIZED BY CIVIL DISTRICTS

POPULATION OF TENNESSEE, 1950 (3)

FIGURE 5

TABLE 2

POPULATION IN GROUPS OF PLACES, 1950[3]

| | SIZE OF PLACE | NUMBER OF PLACES | POPULATION |
|---|---|---|---|
| URBAN | 100,000 OR MORE | 4 | 826,117 |
| | 50,000 - 100,000 | 0 | . . . |
| | 25,000 - 50,000 | 3 | 88,300 |
| | 10,000 - 25,000 | 9 | 123,814 |
| | 5,000 - 10,000 | 24 | 169,305 |
| | 2,500 - 5,000 | 31 | 112,710 |
| | UNDER 2,500 | 3 | 3,260 |
| | OTHER URBAN | . | 129,096 |
| | TOTAL URBAN | 74 | 1,452,602 |
| RURAL | 1,000 - 2,500 | 73 | 114,658 |
| | UNDER 1,000 | 114 | 52,504 |
| | OTHER RURAL | . | 1,671,954 |
| | TOTAL RURAL | 187 | 1,839,116 |

air pollution and the need for appropriate control measures will undoubtedly grow. It was pointed out in a recent publication,[6] "The indication that the total particulate loading in the air over a community is, very broadly, related to the number of persons contributing to it is striking."

TABLE 3

POPULATION AND LAND AREA OF URBANIZED AREAS, 1950[3]

| URBANIZED AREA | POPULATION | AREA (SQ.MI.) | DENSITY (POP. PER SQ. MI.) |
|---|---|---|---|
| CHATTANOOGA AREA | 167,764 | 50.4 | 3329 |
| CITY | 131,041 | 28.0 | 4680 |
| URBAN-FRINGE | 36,723 | 22.4 | 1639 |
| KNOXVILLE AREA | 148,166 | 35.6 | 4162 |
| CITY | 124,769 | 25.4 | 4912 |
| URBAN-FRINGE | 23,397 | 10.2 | 2294 |
| MEMPHIS AREA | 406,034 | 109.6 | 3705 |
| CITY | 396,000 | 104.2 | 3800 |
| URBAN-FRINGE | 10,034 | 5.4 | 1858 |
| NASHVILLE AREA | 258,887 | 53.7 | 4821 |
| CITY | 174,307 | 22.0 | 7923 |
| URBAN-FRINGE | 84,580 | 31.7 | 2668 |

## SOURCES OF POLLUTION

### Pollution from Use of Fuel

*Use of fuels generally:* The combustion of fuel for space heating, for power, in industry, and transportation results in the release of large quantities of pollutants in the forms of gases, and solid and liquid particles. The types and amounts of pollutants emitted by use of fuel are affected by such items as kind of fuel, type and condition of firing equipment, load demands, firing practice, use of collection devices, etc. This general discussion will concern fuel usage by type of fuel, class of consumer, and geographic area.

Tennessee has available all three of the principal fuels, namely, coal, natural gas, and petroleum, as well as extensive electric power. The coal fields of the Cumberland Mountains produce numerous grades of bituminous coal, most of which are favored for steam-powered generation. Kentucky coals are also used. Natural gas is available generally throughout most of Tennessee. Natural gas comes from Louisiana and Texas and is distributed by seven pipeline companies. Tennessee produces only a small amount of petroleum but is in relatively close proximity to the major petroleum-producing and refining centers of the Gulf Coast area. Access to these fields is furnished by both pipeline and barges operating on inland waterways (90 percent of the fuel oil delivered to Tennessee moves by barges). Electric power generated in Tennessee is supplied almost entirely by the TVA from

TABLE 4

FUEL CONSUMPTION IN TENNESSEE, 1954[7] [13] [14]

| FUEL | AMOUNT | TRILLIONS OF B.T.U.(a | PERCENT OF B.T.U. |
|---|---|---|---|
| COAL (b) | 3,641,000 TONS | 84 | 20 |
| FUEL OIL | 4,181,000 BBLS. | 25 | 6 |
| KEROSENE | 2,397,000 BBLS. | 14 | 3 |
| GAS | 1.1089 BILLION THERMS | 111 | 26 |
| L.P. GAS (c) | 32,518,000 GALS. | 3 | 1 |
| ELECTRICITY | 21.5 BILLION KW.-HRS. | 73 | 17 |
| GASOLINE | 922,078,000 GALS. | 113 | 27 |

(a) Potential, assuming 100 percent efficiency in combustion.
(b) Does not include coal burned for the purpose of generating electricity.
(c) Liquid petroleum gas.

hydroelectric plants and coal-fired, steam-electric plants. All the major fuels are readily available and use of one particular fuel does not predominate (Table 4).

In addition, a considerable amount of wood is burned for fuel, particularly in rural areas. Use of wood for fuel is estimated at about 10 trillion B.t.u. or 550,000 tons.

Data on the nature and extent of pollutants emitted from fuel-burning installations are presented in Appendix B. However, no calculations of pollution emissions will be made in this report because of lack of sufficient specific information upon which to base such computations.

*Use of coal:* The amount of coal consumed in Tennessee in 1954 for all purposes was 8,451,000 tons, all of which was bituminous. Usage was distributed as follows:

| | | |
|---|---|---|
| Coke and gas plants...... | 40,000 | tons |
| Retail dealers........... | 1,514,000 | " |
| TVA (plants in Tennessee)............ | 4,786,000 | " |
| Other steam-electric plants........ | 24,000 | " |
| All others............... | 1,903,000 | " |
| Not in open market....... | 184,000 | " |

Coal has been in decreasing demand for most uses in recent years. Excluding coal consumption by electric utilities, coal usage dropped 47 percent between 1948 and 1954, as indicated below:

| | | |
|---|---|---|
| 1948.................. | 6,130,000 | tons[14] |
| 1949.................. | 5,676,000 | " [14] |
| 1954.................. | 3,241,000 | " |

This trend reflects the conversion of railroads to the use of diesel engines, the decrease in coke oven use (258,000 tons in 1949 compared with 40,000 tons in 1954), the conversion to gas in industry (3,055,000 tons of coal in 1947 compared with perhaps 2,000,000 tons in 1954), the conversion of residential heating plants from coal to gas or oil, and the use of gas and electric heat in newly constructed houses.

There has been, however, an increasing use of coal by the electric utilities (TVA), as indicated below:

| | | |
|---|---|---|
| Early thirties....... | 87,000 | tons |
| Early forties........ | 738,000 | " |
| 1950................. | 870,000 | " |
| 1954................. | 4,786,000 | " |
| 1956................. | 8,884,000 | " |

It is expected that both these trends will continue, i.e., increasing use for generation of electricity and decreasing use residentially and elsewhere.

Coals used in Tennessee are supplied from Tennessee, Kentucky (east and west), and Virginia (west) mines and have the following "typical" analysis:

| | | |
|---|---|---|
| Volatile matter.... | 30 to 38 | percent |
| Fixed carbon....... | 47 to 59 | " |
| Ash................ | 5 to 9 | " |
| Sulfur............. | 1 to 3 | " |

*Use of fuel oil:* A total of 4,181,000 bbls. of fuel oil were used in Tennessee in 1954. This figure increased to 4,775,000 bbls. in 1955. Distribution of fuel oil usage is shown in Table 5.

Use of fuel oil by railroads, river vessels, industry, and for space heating has been increasing in recent years. The

TABLE 5

USE OF FUEL OIL IN TENNESSEE--1955[10]
(THOUSANDS OF 42-GALLON BBLS.)

| USER | DISTILLATE | RESIDUAL | TOTAL |
|---|---|---|---|
| RAILROADS | 1,756 | 5 | 1,761 |
| VESSELS | 80 | 404 | 484 |
| ELECTRIC POWER PLANTS | 2 | 3 | 5 |
| INDUSTRIAL | 311 | 234 | 545 |
| OIL COMPANY FUEL | 27 | 3 | 30 |
| HEATING OIL | 799 | 175 | 974 |
| MILITARY | 17 | 92 | 109 |
| MISCELLANEOUS | 784 | 14 | 798 |
| RANGE OIL | 69 | - | 69 |
| TOTALS | 3,845 | 930 | 4,775 |

increase from 1954 to 1955 for major users was 110,000 bbls. by railroads; 200,000 bbls. by river vessels; 55,000 bbls. by industry; and 68,000 bbls. for space heating. The increase in fuel oil usage for space heating purposes since 1950 is shown by the following annual use data:

1950.....848,000 bbls.
1952.....909,000 "
1954.....906,000 "
1955.....974,000 "

In addition to fuel oil, 2,397,000 bbls. of kerosene were used in Tennessee in 1954. Of this, 1,661,000 bbls. were used for range oil, 67,000 bbls. for tractor fuel, and 669,000 bbls. for all other uses.

*Use of gas:* Gas usage in Tennessee in 1955 was 1,155.9 million therms, of which 1,151.1 million therms was natural gas and 4.8 million therms was manufactured gas, used only in industry. Distribution by user is indicated in Table 6.

TABLE 6

AMOUNT OF GAS USED IN TENNESSEE--1955[8]
(MILLIONS OF THERMS)

| USER | TOTAL GAS |
|---|---|
| RESIDENTIAL | 222.1 |
| COMMERCIAL | 152.4 |
| INDUSTRIAL | 522.2 |
| OTHER | 259.2 |
| TOTAL | 1,155.9 |

The use of natural gas has been increasing steadily (Table 7). This increase has been due both to greater use in areas already served and to expansion of service into new areas, as in eastern and northeastern Tennessee in the past two years.

It is expected that the use of gas will continue to increase, but it should be noted that the rate of increase from year to year has been lessening.

In addition to natural gas, 32,518,000 gallons of liquid petroleum gas, with a potential heating value of three trillion B.t.u.'s were also used in 1954. Of this amount, 25,935,000 gallons were used for domestic and commercial purposes, 1,579,000 gallons for gas manufacturing, 1,927,000 gallons for industrial purposes, 98,000 gallons for synthetic rubber manufacturing, 1,542,000 gallons by the chemical industry, 1,243,000 gallons in internal combustion engines, and 194,000 gallons for all other purposes.

*Residential fuel usage:* In 1950 coal was the most popular fuel for home heating. The state-wide use of fuel for residential heating is shown in Table 8.

Certain trends in home heating are apparent. In more recent years (since 1950) the trend has been away from the use of coal and wood. Use of gas is continuing to expand but probably not at as great a rate as previously. Within the past few years, gas service has been extended to northeastern Tennessee. Liquid fuels, popular in eastern Tennessee, probably will not gain as much as previously because of competition from natural gas. Use of electricity for home heating, particularly for new homes, is increasing in urban "fringe areas." In the western section of the State gas is the primary fuel, whereas coal predominates in the rest of the State (Table 9).

TABLE 7

USE OF NATURAL GAS IN TENNESSEE[8]

| YEAR | 1946-50 (AVG.) | 1951 | 1952 | 1953 | 1954 | 1955 |
|---|---|---|---|---|---|---|
| TOTAL GAS CONSUMTION IN MILLIONS OF THERMS | 395.1 | 826.0 | 950.9 | 1,025.3 | 1,108.9 | 1,155.9 |

TABLE 8

FUEL FOR RESIDENTIAL HEATING[15]

| FUEL | PERCENT OF HOMES HEATED BY GIVEN FUEL | | | | |
|---|---|---|---|---|---|
| | 1940 | 1950 | | | |
| | STATEWIDE | STATEWIDE | URBAN | RURAL NONFARM | RURAL FARM |
| COAL | 56.1 | 49.2 | 52.6 | 54.1 | 39.3 |
| WOOD | 39.6 | 21.4 | 3.4 | 22.0 | 52.1 |
| GAS | 3.2 | 14.3 | 27.1 | 4.2 | 1.2 |
| LIQUID | 0.6 | 8.5 | 9.6 | 11.7 | 4.2 |
| ELECTRIC | * | 3.7 | 4.1 | 5.1 | 2.0 |
| OTHER | 0.5 | 2.9 | 3.2 | 2.9 | 1.2 |

Residential consumption of fuel is not evenly distributed over the year but is proportional to the number of degree-days, (Table 10). Residential contribution to air pollution is disproportionately higher in the early and late parts of the heating season when furnaces are run on an intermittent basis than during the main part of the heating season.

*Industrial fuel usage:* Annual industrial fuel usage is estimated as 2,100,000 tons of coal, 580,000 bbls. of oil, and 522 million therms of gas.

*Use of fuel for electric power by TVA:* Power generated by the Tennessee Valley Authority serves practically the entire State as well as parts of Kentucky, Mississippi, Alabama, Georgia, North Carolina, and Virginia. Use of electric power has increased tremendously in Tennessee. In 1954, ultimate consumers in Tennessee used about 21.5 billion kw.-hrs., whereas in 1956, consumption rose to 33.7 billion kw.-hrs. Electric power is generated at hydroelectric and steam-electric plants. In 1954, the TVA generated 10.2 billion kw.-hrs. at hydro stations and 22.2 billion kw.-hrs. at steam stations. In 1956, these figures were 11.9 and 44.5 respectively. Few sites for hydro projects remain undeveloped in this region. This hydro potential is small in relation to the rapidly increasing demands for electricity. Accordingly, load growth on the TVA system must be met chiefly by steam-electric generating plants. In 1954, the TVA operated five coal-fired steam-electric plants in Tennessee which burned 4,786,000 tons of coal. In 1956, TVA operated seven plants in the State, with a total coal consumption of 8,884,000 tons--an increase of 85 percent. Three of these plants consumed 8,649,000 tons of coal or 97 percent of the total. In 1956, TVA also operated four coal-fired steam-electric plants outside the State, which consumed a total of 9,221,000 tons of coal. The larger TVA steam plants burn from 1.5 to 4.5 million tons of coal per year. From these plants a large amount of gaseous and particulate matter is emitted to the atmosphere. The King-

TABLE 9

USE OF FUEL IN RESIDENTIAL HEATING, 1950[15]

(PERCENT OF DWELLING UNITS HEATED BY SPECIFIED FUEL)

| FUEL | MEMPHIS | NASHVILLE | CHATTANOOGA | KNOXVILLE | BRISTOL |
|---|---|---|---|---|---|
| COAL | 16 | 65 | 67 | 79 | 86 |
| WOOD | 6 | 1 | 0 | 1 | 1 |
| GAS | 73 | 17 | 5 | 1 | 1 |
| LIQUID | 3 | 8 | 14 | 11 | 4 |
| ELECTRICITY | 0 | 6 | 9 | 5 | 6 |
| OTHER | 2 | 3 | 5 | 3 | 2 |

TABLE 10

NORMAL NUMBER OF DEGREE DAYS FOR SEVERAL CITIES[16]

| MONTH | MEMPHIS | NASHVILLE | CHATTANOOGA | KNOXVILLE | BRISTOL |
|---|---|---|---|---|---|
| JANUARY | 725 | 778 | 725 | 760 | 818 |
| FEBRUARY | 591 | 656 | 607 | 650 | 720 |
| MARCH | 427 | 498 | 467 | 500 | 576 |
| APRIL | 139 | 186 | 179 | 196 | 294 |
| MAY | 24 | 43 | 45 | 50 | 95 |
| JUNE | 0 | 0 | 0 | 0 | 0 |
| JULY | 0 | 0 | 0 | 0 | 0 |
| AUGUST | 0 | 0 | 0 | 0 | 0 |
| SEPTEMBER | 17 | 22 | 24 | 33 | 58 |
| OCTOBER | 126 | 154 | 169 | 179 | 239 |
| NOVEMBER | 432 | 471 | 477 | 498 | 576 |
| DECEMBER | 673 | 725 | 710 | 744 | 815 |
| TOTALS | 3,137 | 3,513 | 3,384 | 3,590 | 4,148 |

ston plant, for example, burning 4,586,000 tons of coal per year (1956) would emit approximately 1.5 million lbs. of sulfur dioxide per day. The management of TVA has recognized the need for air pollution control and has inaugurated a constructive plan of air pollution studies.

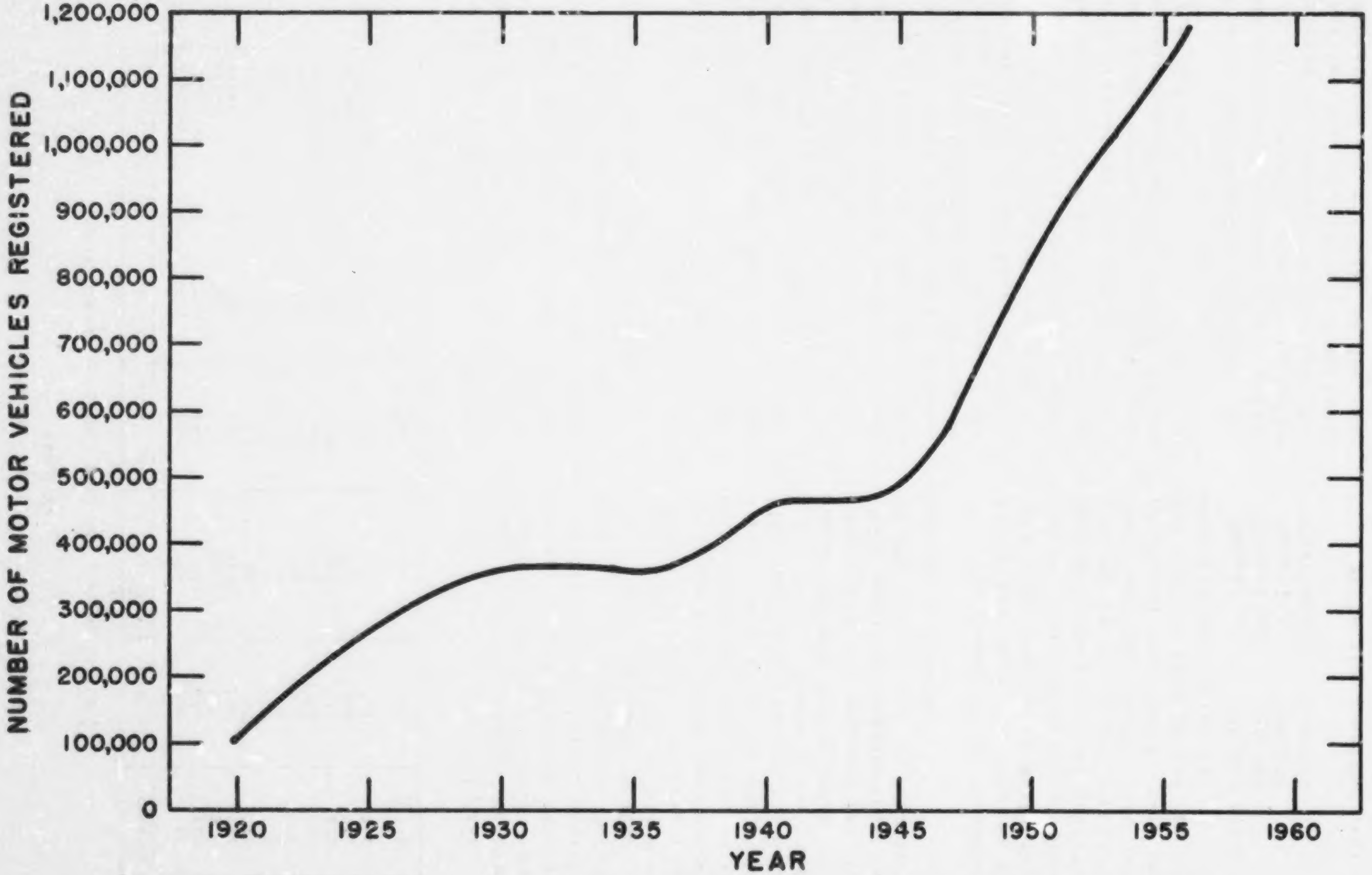
All major TVA steam plants are equipped with mechanical fly-ash collectors, designed to remove about 85 percent of the fly-ash. Most plants are located in rural areas and no fly-ash nuisance is expected. However, provision has been made in the initial design for installation of electrostatic precipitators, should they be needed. In this State survey, no complaints concerning TVA steam plants were encountered. Some apprehension was expressed concerning fly-ash, sulfur dioxide, and fluoride emissions of the Kingston plant. It should also be pointed out that the TVA, upon receipt of atmospheric stagnation alerts from the U.S. Weather Bureau's stagnation warning service,[17] modifies plant operations at Kingston to reduce emission of sulfur dioxide by use of low sulfur coal.

*Use of fuel in motor vehicles:* The role of automobile exhaust in air pollution is of increasing concern in large communities throughout the country. Motor vehicles emit significant quantities of hydrocarbons and nitrogen oxides, and relatively smaller amounts of aerosols, sulfur oxides, aldehydes, ammonia, organic acids, and other organic compounds.[18] Other pollutants result from the use of additives to gasoline such as tetraethyl lead, boron, phosphorous compounds, and detergents. Motor oils and their additives are another source of pollution. Data on emission of pollutants from motor vehicles are given in Appendix B. In 1956, there were 1,179,301 motor vehicles registered in the State[19] --one automobile for every 3.0 people. (The national average is one for every 3.4 people.) These motor vehicles consumed 982,012,160 gallons of gasoline, some 2,690,000 gallons per day. During 1955, monthly consumption varied from 90,961,000 gallons in July to 65,488,000 gallons in February.[13]

The number of motor vehicles in the State has been increasing at a great rate since the end of World War II, (Figure 6). Concentration of population in metropolitan areas, of course, is accompanied by a concentration of motor vehicles. From traffic flow data,[21] it is estimated that the 24-hour annual average traffic flow in and out of the four metropolitan cities is:

| | | | |
|---|---|---|---|
| Memphis...... | 130,000 | motor | vehicles |
| Nashville.... | 185,000 | " | " |
| Knoxville.... | 100,000 | " | " |
| Chattanooga.. | 110,000 | " | " |

While the specific over-all effect of emissions from vehicle exhausts is



GROWTH IN MOTOR VEHICLE REGISTRATION (20)
FIGURE 6

impossible to estimate within the scope of this study, cognizance should be taken of their substantial contribution to the over-all pollution load of the urban atmosphere and to their increasingly important role as a pollution source as population and traffic increase.

*Use of fuel by railroads:* Fourteen important railway systems serve Tennessee, either directly or through subsidiary lines. Main-line trackage of the State in 1944 totaled 3,546 miles. The vast majority of the trains operated by these companies use diesel-electric locomotives as their prime movers. It is rare indeed to see a coal-burning locomotive. Switching engines, in urban areas, are exclusively diesel-powered, with the exception of Bristol, Virginia.

The contribution of these diesel-powered railroad locomotives to dustfall and dirtiness is relatively insignificant. However, operation of diesel engines results in emission of a variety of combustion products, (Appendix B). A diesel engine burns about two gallons of oil per mile, whereas diesel switch engines burn six to eight gallons per locomotive yard-hour.[22] The railroads in Tennessee bought 1,761,000 bbls. of fuel oil in 1955. As with auto traffic, the heaviest traffic of locomotives and switch engines is in the large centers of population. Memphis is served by 9 railway systems, Nashville by 3, Chattanooga by 4, and Knoxville by 2. Consideration must be given to their contribution to the caldron of pollution over the cities, but it may be considered to be a relatively minor factor.

*Use of fuel by river vessels:* The inland waterways system of Tennessee consists of three major rivers; the Mississippi, the Tennessee, and the Cumberland, with a total of about 1,000 miles of navigable nine-foot channels. For the year 1947, tonnages on these rivers were:

| | |
|---|---|
| Memphis (Mississippi River).. | 2,050,000 |
| Tennessee River............. | 2,890,000 |
| Cumberland River............ | 1,280,000 |

Most of these vessels are diesel powered. Vessel companies in Tennessee bought 484,000 bbls. of fuel oil in 1955. The contribution of air pollutants from this source is considered minor.

### Pollution from Industry

*General nature of industry:* Tennessee is in the process of a change from a highly agricultural-rural economy to a more industrialized-urban one. Not until 1910 did manufacturing surpass agriculture in total value of products, and only in the past few years has manufacturing employed more people than agriculture. The emphasis of Tennessee's

TABLE 11

EMPLOYMENT BY MAJOR INDUSTRIAL GROUPS, 1950[20]

| INDUSTRY | PERCENTAGE OF EMPLOYEES | | RATIO |
|---|---|---|---|
| | U.S. | TENN. | TENN./U.S. |
| AGRICULTURE, FORESTRY, AND FISHERIES | 12.5 | 21.9 | 1.76 |
| MINING | 1.6 | 1.3 | 0.77 |
| CONSTRUCTION | 6.1 | 7.0 | 1.15 |
| MANUFACTURING: | | | |
| TOTAL | 25.9 | 21.1 | 0.81 |
| DURABLE GOODS | 13.8 | 7.8 | 0.57 |
| NONDURABLE GOODS | 12.1 | 13.2 | 1.09 |
| TRANSPORTATION, COMMUNICATION, AND UTILITIES | 7.8 | 6.7 | 0.86 |
| WHOLESALE AND RETAIL TRADE | 18.8 | 17.0 | 0.91 |
| FINANCE, INSURANCE, AND REAL ESTATE | 3.4 | 2.3 | 0.66 |
| BUSINESS SERVICES | 2.5 | 2.1 | 0.83 |
| PERSONAL SERVICES | 6.2 | 7.3 | 1.18 |
| ENTERTAINMENT AND RECREATIONAL SERVICES | 1.0 | 0.7 | 0.71 |
| PROFESSIONAL SERVICES | 8.3 | 7.5 | 0.90 |
| PUBLIC ADMINISTRATION | 4.4 | 3.3 | 0.74 |
| ALL OTHERS | 1.5 | 1.8 | 1.24 |

TABLE 12

NONAGRICULTURAL EMPLOYMENT, 1955[20]

| INDUSTRY | PERCENTAGE OF EMPLOYEES | | RATIO |
|---|---|---|---|
| | U.S. | TENN. | TENN./U.S. |
| MINING | 1.5 | 1.0 | 0.70 |
| CONSTRUCTION | 5.1 | 5.6 | 1.10 |
| MANUFACTURING | 33.5 | 34.4 | 1.03 |
| TRANSPORTATION, COMMUNICATION, AND UTILITIES | 8.2 | 6.8 | 0.83 |
| TRADE | 21.7 | 22.9 | 1.05 |
| FINANCE, INSURANCE, AND REAL ESTATE | 4.4 | 3.3 | 0.75 |
| SERVICES, GOVERNMENT, AND MISCELLANEOUS | 25.5 | 25.9 | 1.07 |

industrial economy is upon the processing of basic resources (generally produced in the State), usually no further than the semifinished stage.

Table 11 shows the distribution of employment in Tennessee as compared to the United States.

From these data it is apparent that Tennessee has a large agricultural industry; indeed, Tennessee has always been considered an agricultural state. In 1950, however, agricultural and manufacturing employment were about equal. More recent data (1955) indicate that Tennessee has had a growth in the manufacturing, trade, and finance industries, with others declining somewhat. The largest gain was in the manufacturing industries, with an increase from 239,427 persons employed in 1950 to 291,300 in 1955. These data are given in Table 12, which shows that manufacturing in Tennessee accounted for 34.4 percent of the nonagricultural employment.

*The agricultural and forestry industries and air pollution:* Farming has been the backbone of Tennessee's economic development. Only in recent decades, particularly since the development of cheap electric power, has manufacturing come into equal and greater prominence.

Combined value of crops in 1955 amounted to $345,575,000, of which the leaders were cotton, corn, tobacco, and hay. Cash receipts from farm marketing amounted to $431,087,000 in 1955, divided evenly between livestock and crops, (Table 13).

Cotton, the State's leading money crop, is grown mainly in west Tennessee, particularly the extreme southwestern part. The cotton crop furnishes raw materials for the extensive local textile industry, (cotton fabrics, chemical cotton, rayon and cellulose acetate yarn) film base, and plastics. Processing of cottonseed for the oil is a leading industry at Memphis. Corn is Tennessee's

TABLE 13

CASH RECEIPTS FROM FARM MARKETING AND VALUE OF PRODUCTS CONSUMED ON FARMS, 1955[23]

| ITEM | CASH RECEIPTS FROM FARM MARKETING | VALUE OF PRODUCTS CONSUMED ON FARMS |
|---|---|---|
| LIVESTOCK AND PRODUCTS | $210,582,000 | $52,612,000 |
| CROPS | 220,505,000 | 30,858,000 |
| TOTAL | $431,087,000 | $83,470,000 |
| GOVERNMENT PAYMENTS | 5,611,000 | ... |
| TOTAL | $436,698,000 | ... |

leading acreage crop and is grown throughout the State. Tobacco, particularly burley, the "number 2" cash crop, is raised principally in eastern Tennessee. Other principal crops are wheat, hay, soybeans, strawberries, Irish and sweet potatoes, small grains (barley, rye, oats), fruits and vegetables, peanuts, and farm seed (crimson, red and hop clover, lespedeza, and orchard grass).

Livestock and livestock products constitute nearly half of the State's agricultural cash income. In order of decreasing value, the leading livestock species are cattle and calves, milk cows, hogs and pigs, horses and mules, chickens, sheep and lambs, and turkeys. Cattle and milk cows are raised mainly in the central basin, while hogs and horses are raised principally in western Tennessee.

Pollution from agricultural operations involves the cotton ginning industry. Lint from this processing has been cited generally in western Tennessee as a local nuisance problem. It is seasonal in nature, occurring in the fall of the year. Aside from the general odor problems concerned with animal raising (in populated areas), no other problems have been reported.

Forest products are a major source of income in Tennessee. In 1950, for example, money income from this source was $146,000,000, which was six percent of the State's total from all private industry. The investment in woodworking industry. The investment in woodworking plants is an extremely important factor in the economic life of the State. Sawmills number nearly 2800; in addition, there are 5 pulp mills, 14 veneer mills, 38 cooperage plants, and about 140 miscellaneous plants.[24] Altogether they employ twenty-six thousand people--10 percent of the total manufacturing employment.[4] Forests cover 12.6 million of the State's 26.9 million acres. The present annual growth on all forest lands is 286 million cubic feet of wood, whereas the amount cut for commercial and domestic use is 252 million cubic feet. Air pollution from industries based on use of timber is considered herein under several manufacturing industries. No adverse effects of air pollution on the timber economy have been reported in recent years.

TABLE 14

MINERAL PRODUCTION, 1954[25]

| MINERAL | SHORT TONS | VALUE (DOLLARS) |
|---|---|---|
| COAL | 6,700,000 | 32,000,000 |
| STONE | 14,040,187 | 22,046,016 |
| CEMENT | 1,423,024 | 19,734,262 |
| PHOSPHATE ROCK | 1,829,213 | 11,743,012 |
| ZINC | 30,326 | 6,550,345 |
| SAND AND GRAVEL | 5,155,226 | 6,141,139 |
| COPPER | 9,087 | 5,361,861 |
| CLAYS | 1,015,256 | 3,780,952 |
| LIME (1953) | 114,474 | 1,177,461 |
| MANGANESE ORE | 11,823 | 919,949 |
| BARITE | 12,415 | 202,479 |
| SILVER (TROY OUNCES) | 60,759 | 54,990 |
| IRON ORE (1953) | 14,281 | 82,499 |
| NATURAL GAS (MILLION CU.FT., 1953) | 89 | 11,000 |
| GOLD (TROY OUNCES) | 218 | 7,630 |
| LEAD (1953) | 9 | 2,358 |
| UNDISTRIBUTED (1954) | ... | 6,252,989 |

*The mining industry and air pollution:* Tennessee embraces one of the most diversified assemblages of mineral resources in the country. There are about 30 economically important minerals. Except for ball clays found in west Tennessee, phosphate found in middle Tennessee, and sand and gravel widely distributed throughout the State, most mineral resources are found in east Tennessee. The value of mineral production in Tennessee in 1954 was $112,206,000, an all-time high for the State. Five mineral commodities have dominated the mineral industries--coal, cement, stone, zinc and phosphate rock. These five commodities together have constituted 83 to 85 percent of the total mineral output of Tennessee in the past five years. Mineral production in the State is shown in Table 14.

Coal production in Tennessee is centered in the Cumberland plateau region, principally Campbell, Marion, Claiborne, Anderson, and Putnam Counties. No air pollution problems from this industry were reported. Stone production comprises the output of limestone, marble, sandstone, and miscellaneous stone. Production of crushed limestone (1954), used principally for road paving, construction, agricultural lime, lime and cement manufacture, railroad ballast, and as a flux in blast furnaces, constituted over 99 percent of the total tonnage of stone quarried. Limestone was produced in all parts of the State except west Tennessee. Dust from crushing limestone has been noted as a local pollution problem in many locales of the State. Cement production is confined largely to east Tennessee. In 1954 there were six plants in the State producing cement. Emissions of cement dust have been noted as a local dust nuisance. Phosphate rock, mined chiefly in Maury and Giles Counties of south middle Tennessee is used in making phosphoric acid, elemental phosphorus, ferrophosphorus, and superphosphates, and for direct application to the soil. Tennessee is the second largest phosphate rock producer in the United States. Air pollution from the mining of phosphate rock and its subsequent treatment will be covered in a later section of this report. Of the remaining mineral industries, some dust problems have been noted in connection with the production of fuller's earth and clays in western Tennessee.

*The manufacturing industry and air pollution:* "Modern Tennessee has come of age industrially."[4] With the value added by manufacturing at $1,678,300,000 and an annual payroll of $851,100,000 (both 1954), manufacturing today contributes over 20 percent of the total gross income of Tennesseans, while agriculture contributes only about 10 percent. General manufacturing statistics for the State are given in Table 15. These figures show a substantial growth in the period 1947 through 1954.

Tennessee's industrial economy is complex and varied, but the emphasis remains upon processing basic resources, usually not beyond the semifinished stage. In both value of product and employment, chemicals constitute the State's leading manufacturing group. Next are (according to value of products, 1954) food, textiles, fabricated metals, primary metals, apparel, lumber and wood products, printing and publishing, and pulp and paper. Pertinent data are given in Table 16.

Manufacturing in Tennessee currently is concentrated in the four metropolitan areas--Chattanooga, Knoxville, Memphis, and Nashville--and in Sullivan County. These five leading industrial centers accounted for over two-thirds of the State's total value added by manufacturing in 1954. Regionally, east Tennessee, with its excellent mineral and water resources, has paced the State's industrial development and has accounted for the major share of the State's manufacturing.

On the basis of employment, east Tennessee predominates in textile, apparel, chemical and primary and fabricated metal industries; middle Tennessee is dominant in printing and publishing and leather industries, with good representation in food and chemicals; and west Tennessee leads in lumber and wood

TABLE 15

GENERAL MANUFACTURING STATISTICS FOR 1954 AND 1947[26]

| ITEM | UNIT OF MEASURE | 1954 | 1947 | PERCENT CHANGE 1947-54 |
|---|---|---|---|---|
| NUMBER OF ESTABLISHMENTS, TOTAL | NUMBER | 4,060 | 3,345 | +21 |
| 1-19 EMPLOYEES | NUMBER | 2,696 | 2,122 | +27 |
| 20-99 EMPLOYEES | NUMBER | 823 | 765 | + 8 |
| 100 OR MORE EMPLOYEES | NUMBER | 541 | 458 | +18 |
| ALL EMPLOYEES | | | | |
| NUMBER | THOUSANDS | 261.2 | 222.3 | +17 |
| PAYROLL | MILLION DOLLARS | 851.1 | 476.6 | +79 |
| VALUE ADDED BY MANUFACTURE | MILLION DOLLARS | 1,678.3 | 961.4 | +75 |
| CAPITAL EXPENDITURES, NEW | MILLION DOLLARS | 152.3 | 83.8 | +82 |

TABLE 16

MANUFACTURING STATISTICS, 1947 AND 1954[26]

| MAJOR INDUSTRY GROUP (MANUFACTURING) | 1954 | | | | | | | | 1947 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL NO. OF ESTAB-LISH-MENTS | NUMBER OF ESTABLISHMENTS WITH | | | ALL EMPLOYEES | | VALUE ADDED BY MANU-FACTURE ($1,000) | CAPITAL EXPENDI-TURES, NEW ($1,000) | ALL EMPLOYEES NUMBER | VALUE ADDED BY MANU-FACTURE ($1,000) |
| | | 1-19 EMPLOYEES | 20-99 EMPLOYEES | 100 OR MORE EMPLOYEES | NUMBER | PAYROLL ($1,000) | | | | |
| ALL INDUSTRIES, TOTAL | 4,060 | 2,696 | 823 | 541 | 261,220 | 851,137 | 1,678,282 | 152,274 | 222,300 | 961,385 |
| FOOD AND KINDRED PRODUCTS | 743 | 470 | 205 | 68 | 27,379 | 90,339 | 186,049 | 13,231 | 23,382 | 132,489 |
| TEXTILE MILL PRODUCTS | 157 | 30 | 53 | 74 | 32,975 | 83,721 | 139,877 | 6,718 | 35,990 | 121,388 |
| APPAREL AND RELATED PRODUCTS | 177 | 48 | 37 | 92 | 28,825 | 53,179 | 83,642 | 1,403 | 19,017 | 47,533 |
| LUMBER AND WOOD PRODUCTS | 1,230 | 1,062 | 134 | 34 | 17,741 | 40,377 | 68,313 | 3,711 | 20,181 | 56,543 |
| FURNITURE AND FIXTURES | 191 | 114 | 51 | 26 | 10,061 | 27,206 | 43,084 | 1,288 | 7,942 | 26,102 |
| PULP, PAPER AND PRODUCTS | 56 | 10 | 24 | 22 | 7,679 | 30,811 | 62,736 | 27,465 | 4,817 | 35,807 |
| PRINTING AND PUBLISHING | 390 | 321 | 48 | 21 | 10,254 | 40,455 | 67,769 | 3,314 | 9,313 | 46,841 |
| CHEMICALS AND PRODUCTS | 183 | 89 | 51 | 43 | 43,083 | 197,191 | 455,691 | 41,155 | 28,204 | 162,578 |
| LEATHER AND LEATHER PRODUCTS | 65 | 22 | 9 | 34 | 10,807 | 25,726 | 57,306 | 604 | 10,455 | 41,411 |
| STONE, CLAY AND GLASS PRODUCTS | 195 | 141 | 31 | 23 | 8,471 | 25,988 | 48,628 | 4,135 | 8,115 | 31,952 |
| PRIMARY METAL INDUSTRIES | 55 | 23 | 17 | 15 | 11,579 | 45,119 | 92,598 | 23,527 | 15,151 | 86,104 |
| FABRICATED METAL PRODUCTS | 194 | 109 | 52 | 33 | 15,613 | 53,122 | 94,966 | 7,663 | 14,783 | 52,607 |
| MACHINERY EXCEPT ELECTRICAL | 158 | 105 | 39 | 14 | 8,602 | 33,821 | 57,251 | 3,255 | 5,508 | 24,256 |
| ELECTRICAL MACHINERY | 39 | 19 | 14 | 6 | 3,969 | 13,455 | 32,096 | 2,719 | 1,224 | 5,089 |
| TRANSPORTATION EQUIPMENT | 39 | 22 | 9 | 8 | 6,083 | 25,732 | 56,911 | 2,095 | 5,012 | 22,649 |
| MISCELLANEOUS MANUFACTURES | 131 | 83 | 33 | 15 | 8,835 | 31,052 | 45,019 | 5,690 | 2,734 | 8,428 |

products and food products, with apparel and leather well represented. Detailed data on manufacturing employment are given in Appendix C.

Problems of air pollution from the manufacturing industry encountered in this survey are geographically widespread and embrace many of the major manufacturing groups. It is emphasized that these observations are limited to readily detected problems--smoke, dust, fumes and odors--discernible by personal observation. The emissions described are by no means a complete representation of those of all manufacturing establishments.

*The chemical industry and air pollution:* A vast array of materials as odors, gases, liquid and solid aerosols, dusts, and vapors are emitted to the atmosphere by chemical industries. Generally, little or no special effort is made to control emissions, although a number of establishments have done notable jobs of controlling pollution. A partial list of noted materials includes odors, gases (oxides of nitrogen, carbon monoxide and dioxide, sulfur dioxide, carbon disulfide, hydrogen disulfide, aldehydes, ammonia, acetylene, solvents), particulate matter (fluorides, aluminum and magnesium compounds, calcium arsenate, chlorinated hydrocarbons, dusts, organic material, sodium sulfite, organic vapors, methyl methacrylate, hydrocarbons, insecticides, oxides of phosphorus), and acids (phosphoric, tannic, sulfuric, organic), as well as other materials such as xanthate, ammonium polysulfide, acetate, and smoke. Primary complaints concern odors and dusts.

*The metals industries and air pollution:* This group of industries emit a vast array of material such as smoke, dust, fumes, and organic material. Some companies have installed collection devices, but the majority have not. One general source of pollutants are the foundry cupolas which are largely uncontrolled. Pollutants from the metals industries include smoke, fumes (lead, lead oxide, zinc, magnesium), dusts (silica, ferrosilica, ferrochrome, manganese, metallic, fluorides, carbon, ammonium chloride, alkalies, tetanium tetrachloride, magnesium chloride), organic material (paint spray, acids, tars, asphalt, solvents), and other materials such as sulfide odors, ammonia, and chlorine.

*Other manufacturing industries and air pollution:* Air pollution problems associated with the food industry include odors from slaughter houses, cheese plants, other milk processors and oil processors, and dust from grain milling companies. Some lint problems are reported due to the operation of textile manufacturing plants. The lumber, wood and furniture industries have been reported to create problems by the burning of wood wastes, by discharge of sawdust and paint spray mists, and by odor emission from paint solvents and from creosote treatment of poles. The printing and publishing industry is reported to emit chromic acid, ink solvents, lead fumes, and unspecified odors. The pulp and paper products industry is of concern principally because of the emission of materials which cause a strong, unpleasant odor over a rather large area near pulp mills. There are other dusts and mists discharged from some plants. The leather industry creates some problems because of emission of solvent and other odorous materials. The stone, clay, and glass industries emit odors, smoke, and a variety of dusts including silica, mica, lime, cement, and others. Odor and dust problems are attributed to some plants in the rubber industry and odor problems to tobacco manufacturing establishments.

*Other industry and air pollution:* Dust arising from operations in the construction industry, particularly roadway construction, is frequently cause for public complaint. The trade industries cause emission of pollutants including hydrocarbons from petroleum bulk storage plants and retail filling stations, smoke and odor from automobile scrapping, and odors from restaurants and markets. The service industries are associated with smoke and odor problems created by laundries, odor problems caused by dry cleaning establishments, and smoke emission from hotels.

### Pollution from Refuse Disposal Operations

The disposal method used for garbage and rubbish is an important factor in air pollution. Little or no air pollution should arise from a properly operated sanitary land fill. Properly constructed and operated municipal incinerators should also hold air pollution problems to a minimum, although they emit gaseous combustion products and perhaps limited quantities of smoke, ash, and odor. The burning of refuse on open dumps or by "back yard burning" gives rise to a wide variety of gaseous and particulate matter, including aerosols, oxides of nitrogen and sulfur, aldehydes, organic acids, and other organic material, which are released to the atmosphere. Data on emission of pollutants from burning refuse are given in Appendix B.

In Tennessee, refuse is disposed of on dumps or in land fills. Larger communities tend to dispose of refuse in land fills, while smaller communities more often use open dumps. Municipal incinerators are not used for disposing of refuse, and "back yard burning" is not reported to be a widespread practice in the urban areas.

The four metropolitan communities (Chattanooga, Knoxville, Memphis, and Nashville) operate land fills for disposal of refuse. Chattanooga also burns refuse on one dump within the city limits. In the other municipalities within the State, refuse is disposed of as summarized in Table 17.

TABLE 17

MUNICIPAL DISPOSAL OF REFUSE[27]

| METHOD | NUMBER OF CITIES | TOTAL POPULATION | POPULATION PER CITY |
|---|---|---|---|
| LAND FILL | 22 (a) | 217,851 | 9,000 |
| DUMP | 43 | 146,612 | 3,400 |
| PRIVATE | 4 | 8,115 | 2,000 |
| TOTAL | 69 | 366,492 | . |

(a) Does not include the four metropolitan cities (Chattanooga, Knoxville, Memphis and Nashville) with a population of 826,117.

### Radioactive Materials and Air Pollution

The largest handler of radioactive materials is the Carbide and Carbon Chemicals Company, which operates the U. S. Atomic Energy Commission's facilities at Oak Ridge. These facilities include the electromagnetic plant, the gaseous diffusion plant, and the National Laboratories, with a total employment of approximately 13,600. Also located at Oak Ridge are the Abbot Laboratories which produce radioactive pharmaceuticals. There are two plants in Tennessee, one at Chattanooga and the other near Bristol, which process raw ore containing thorium and probably other radioactive materials. At Chattanooga, a company which will fabricate nuclear fuel elements, is in the process of obtaining a license for such operation. It is expected that the processing and handling of such materials will increase as industrial usage of radioactive materials becomes more widespread.

The need to protect the general public from any possible hazard from radioactive substances has been recognized by the State, as will be pointed out in a later section.

## TOPOGRAPHY AND CLIMATOLOGY AS RELATED TO AIR POLLUTION

### Relationship Between Meteorology and Air Pollution Problems

With growing industrialization and urbanization, more and more air-borne waste material is being discharged into the atmosphere. The degree to which this material accumulates is largely dependent upon the weather. For instance, the measured concentrations of local air pollutants may vary markedly with changing weather even though the total discharge of pollutants remains relatively constant. In the evaluation of the role meteorology plays in the dispersion of air-borne contaminants, large and small-scale weather patterns, common to the area must be considered. The large-scale patterns can usually be determined from the climatological evaluation of existing weather records available from most U.S. Weather Bureau stations. Small-scale weather patterns, on the other hand, are not always determinable as they are often dependent upon diversified influences of local topography.

Weather factors which largely determine the degree to which the atmosphere can disperse waste gases are: (a) wind speed, direction, and turbulence; (b) stability or, more generally, the resistance to vertical motion of the lower layers of air; and (c) humidity, including condensation forms, particularly fog.[17] The role of wind in effecting transportation and dispersion of pollutants is directly proportional to wind speed. Generally speaking, the higher the wind speed, the better the dispersion of air-borne waste materials. Wind direction, with its variability, plays an important role in the directional transport and lateral spreading of these waste materials.

Stability plays an important role in the meteorological relationship to air pollution. Temperature change with height largely determines the stability of the atmosphere. Temperature normally decreases with height (lapse rate) in the atmosphere. The less the lapse rate, the greater the energy required to effect vertical exchange. When temperature increases with height (negative lapse rate), an inversion condition exists which tends to restrict vertical mixing. Shallow inversions based at or near the earth's surface may be produced nightly under clear skies and with light winds and may inhibit vertical diffusion as long as they persist. This type of inversion usually breaks up in the late morning. If the vertical extent of the inversion is great enough, solar heating during the day may be insufficient to cause the inversion to break up.

The role of humidity, including condensation in the form of drizzle, snow and rain, is not as direct as that of wind and stability.[17] Condensation forms resulting from high humidity may have a direct effect by the "rain out" or removal of gaseous and particulate material during periods of precipitation. The presence of fog usually limits the solar heating, which affects the degree of vertical diffusion in the lower layers of air. Air pollution, on the other hand, may have a direct effect on weather in that it provides condensation nuclei for the formation of fog.

Investigations of known occurrences of air pollution episodes have identified all three of these weather elements as contributing to the accumulation of abnormally high concentrations of air pollution.[17] The simultaneous occurrence of light winds, stable conditions, and fog for brief periods is not particularly a rare phenomenon, especially in hilly country. Experience has suggested that conditions must persist for several days before abnormally high concentration of air pollution occur. Such persistent periods are usually associated with the prolonged stagnation of high pressure systems which dominate the area.

## Climatology of Tennessee: General

Tennessee is a typical middle latitude State of marked seasonal variations in weather as indicated by the frequent transit of migratory "high" and "low" pressure systems. During the winter half of the year, these pressure systems bring warm and cold air masses, winds of constantly changing direction and speed, and fair and stormy weather. During the summer half, the weather moderates considerably as fewer contrasting pressure systems transit the region. Tennessee lies in the westward extension of the

Azores-Bermuda high pressure system.[31] The axis of this extended high pressure belt undergoes a seasonal oscillation, being displaced slightly farther south of Tennessee during the winter and spring and slightly north during late summer. With the oscillation of the axis there is a corresponding shift in the general wind direction. In October a separate high pressure cell appears centered over West Virginia.[31] This cell migrates southward during the fall and winter, moving through eastern Tennessee in November and into central Georgia and Alabama in February. During this period the circulation associated with the high pressure system is accompanied by fair weather, widespread stagnation, and frequent occurrences of fog.

There are large and irregular variations in the annual rainfall distribution over the State as shown in Figure 7.[28] Seasonally, the heaviest rains come in the late winter or early spring, and the driest season is midfall. There are about 115 days of the year with measurable precipitation in the western half of the State and 130 days in the eastern half. Clear skies prevail about 130 days of the year, partly cloudy skies about 115 days, and cloudy skies about 120 days of the year.[28] Sunshine averages about 59 percent of the total possible amount for the State, with winter minimum of 45 percent and a summer maximum of about 66 percent.[28] The average surface wind speed, as measured at the various weather stations throughout the State, is about 8 miles per hour.[16] Wind records from these stations show that the average annual surface wind speeds are generally higher in the western section of the State than in the eastern section. This difference in surface wind structure is due primarily to dissimilarities of the sectional topography throughout the State. The percentage frequencies of wind direction and the average annual wind speeds at various stations in the State are given in the wind rose diagrams, Appendix D, and in Table 18, respectively.

Because of the intimate relationship between climatology and topography, local weather patterns of designated sections of the State will be discussed in greater detail later in this report. Locations of U.S. Weather Bureau stations and other weather facilities from which climatological data were obtained are given in Figure 8.

## Topography of Tennessee: General

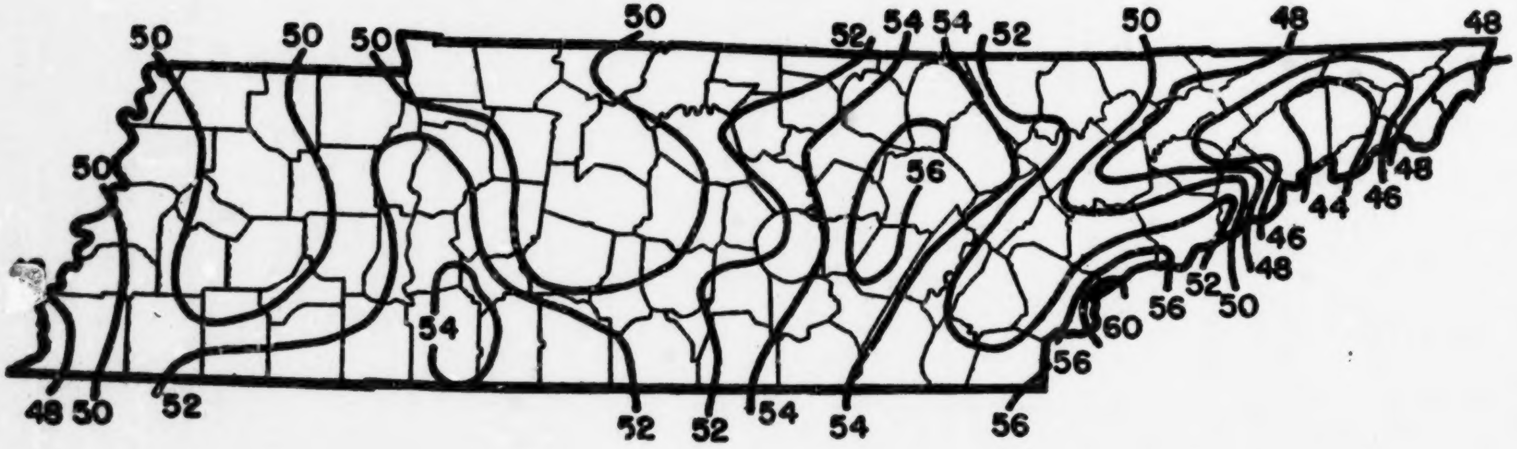
Tennessee, owing to its extreme eastwest extension, crosses three major physiographic provices of the United States and, consequently, presents a variety of land forms. Extending from the Great Smokies of the Appalachians westward to the Mississippi River, the State includes eight well-defined physiographic provinces, or topographic divisions, most of which extend unchanged into the states lying north and south. These provinces conform to the geologic structure of the underlying rocks; thus, the plains and plateaus developed on areas of essentially horizontal rocks and highly folded strata have given rise to the mountainous areas of east Tennessee.[29] These divisions are shown in Figure 9.

TABLE 18

SELECTED CLIMATOLOGICAL CONDITIONS BY AREAS[16, 32]

| AREA | AVERAGE ANNUAL WIND SPEED (M.P.H.) | ANNUAL PREVAILING DIRECTION (SURFACE) | PERCENT CALMS (0-3 M.P.H.) | PERCENT OF POSSIBLE SUNSHINE | DAYS PER YEAR OF HEAVY FOG | RESTRICTED VISIBILITY: CALMS OCCURRING (a) | PERCENT OF OBSERVATIONS WITH VISIBILITY 0-1/2 MILE |
|---|---|---|---|---|---|---|---|
| MEMPHIS | 10.0 | S | 13 | 64 | 5 | 61 | 1.0 |
| NASHVILLE | 8.6 | S | 28 | 59 | 11 | 80 | 1.5 |
| CHATTANOOGA | 6.6 | S | 45 | 56 | 27 | 95 | 2.4 |
| KNOXVILLE | 6.7 | NE | 32 | 56 | 18 | 94 | 2.1 |

(a) Percent of time with restricted visibility (0-1/2 mile) during which calms (0-5 m.p.h.) occurred.


50
50
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48
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44
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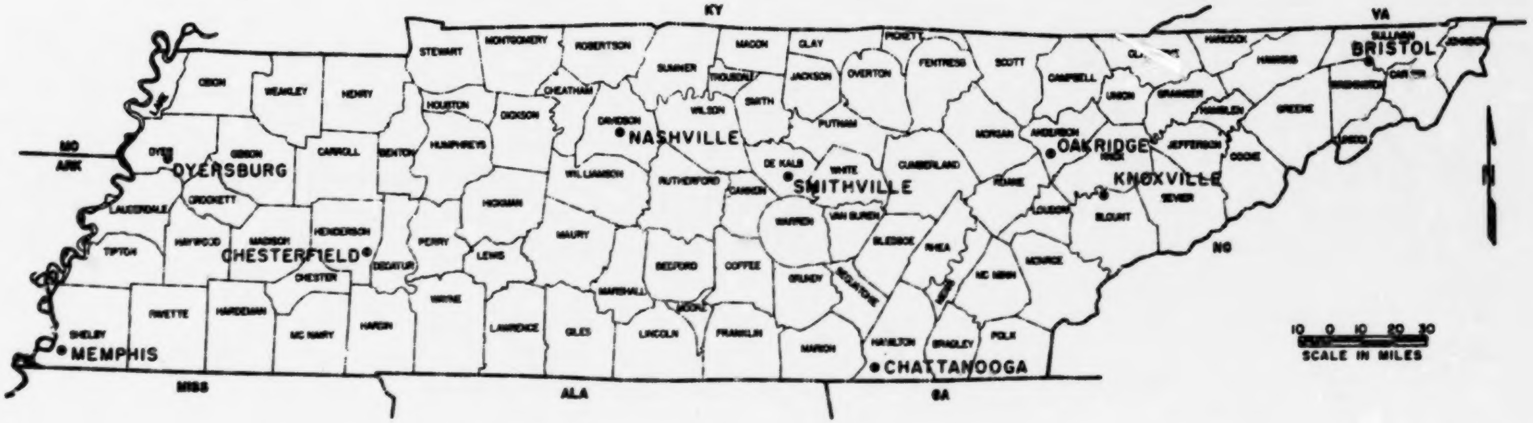
54
54
56

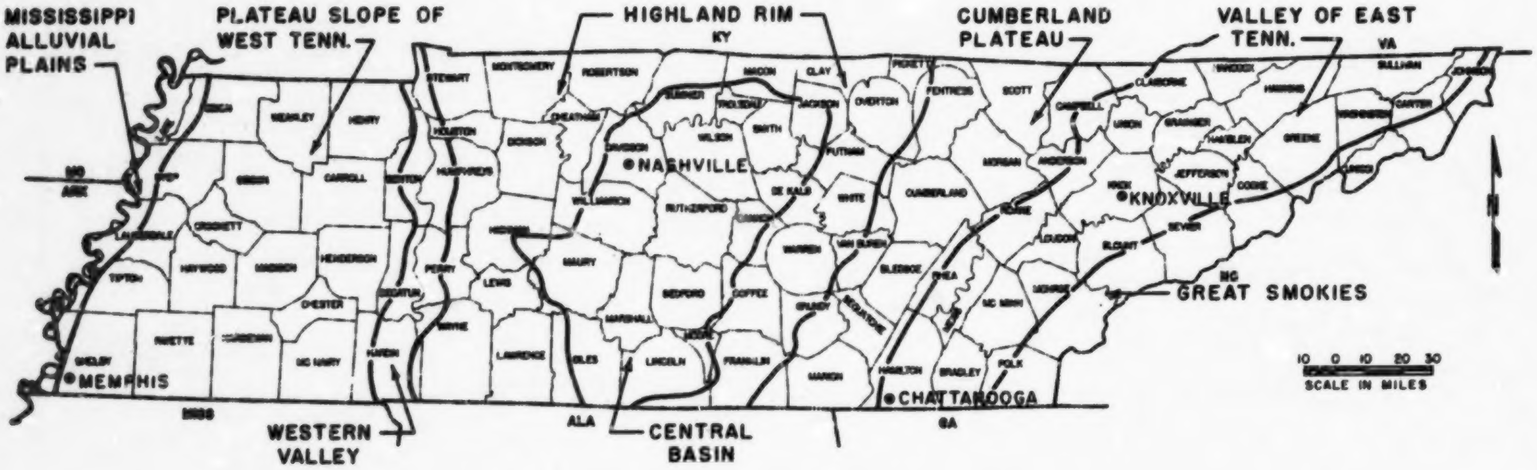
TENNESSEE - AVERAGE ANNUAL PRECIPITATION (INCHES) -(28)

FIGURE 7


KY
VA
MO
ARK
MISS
ALA
GA
NC
BRISTOL
OAKRIDGE
KNOXVILLE
NASHVILLE
SMITHVILLE
CHATTANOOGA
DYERSBURG
CHESTERFIELD
MEMPHIS
N
10 0 10 20 30
SCALE IN MILES

SOURCES OF CLIMATOLOGICAL DATA

FIGURE 8


MISSISSIPPI ALLUVIAL PLAINS
PLATEAU SLOPE OF WEST TENN.
HIGHLAND RIM
CUMBERLAND PLATEAU
VALLEY OF EAST TENN.
GREAT SMOKIES
WESTERN VALLEY
CENTRAL BASIN
KY
VA
NC
GA
ALA
MISS
MO
ARK
MEMPHIS
NASHVILLE
KNOXVILLE
CHATTANOOGA
10 0 10 20 30
SCALE IN MILES

TOPOGRAPHIC DIVISIONS OF TENNESSEE (29)

FIGURE 9

## Topography and Climatology as Related to Air Pollution: Sectional

*Great Smokies: Topography and climatology as related to air pollution:* The Great Smoky Mountains, with a relief of about 4500 feet, make up the most eastwardly physiographic province of Tennessee and present the most rugged surface in the State. The Unaka Range, which forms the Tennessee-North Carolina State line, rises to altitudes from 3000 feet to 6600 feet above sea level, with many westwardly projecting spurs separated by steep, narrow valleys. The province is from 2 to 20 miles wide, with an area of 2600 square miles in Tennessee. The Great Smokies are really a belt composed of two to four parallel ranges which have the crest of the main axis on the North Carolina line. Chilhowee Range, the most westwardly, lies just within the valley of east Tennessee. There is limited level land in this province. The climatology is, in general, favorable for atmospheric dispersion of air-borne waste material as the high elevations give rise to favorable exposures and relatively high wind speeds. There could be a few isolated areas in the high valleys where localized air pollution incidents might occur as a result of topographical influences on the general weather patterns.

*Valley of east Tennessee: Topography and climatology as related to air pollution:* Immediately west of the foothills of the Great Smokies is a lower area of 7,450 square miles, the great valley of east Tennessee, which averages about 45 miles in width and constitutes one of the most important physiographic provinces of the State. This region is characterized by many long, narrow, even-crested ridges, 1200 to 2500 feet in elevation, parelleled by broader, intervening valleys from 600 to 1500 feet above sea level. The ridges and valleys run in a general northeast-southwest direction. The average elevation of the great valley is about 1000 feet above sea level. It slopes gently downward from the northeast. The northeast section of the valley, in the vicinity of Bristol, is about 900 feet higher than the southwestern section of the valley, in the vicinity of Chattanooga. The Tennessee River, forming at Knoxville, flows down the valley to Chattanooga where it leaves the valley to the west through a winding gorge.

Two metropolitan areas and nine cities with over 10,000 population are in this valley area. These cities are between hills or ridges which rise 500 to 1000 feet above them. Such topographical features generally have a pronounced effect on air pollution conditions in the area, particularly during periids of prolonged atmospheric stagnation.

An estimate of the expected frequency of prolonged atmospheric stagnation periods over the Tennessee Valley was made by the U.S. Weather Bureau in connection with the development of a forecasting service for the Tennessee Valley Authority air pollution control program.[17] In this survey, all high pressure systems (the meteorological model most likely to produce prolonged stagnant conditions of the atmosphere) which persisted three days or longer were counted. Sixty-five cases were found over a forty-year period. These cases, distributed by month, are shown in Table 19.

It must be understood, however, that only a small fraction of these cases could have resulted in severe smog conditions with appropriate light wind, stability, and daily fogs. It has been noted that nocturnal inversions are quite frequent in this area, particularly during the fall. A study of five mountain

TABLE 19

TOTAL NUMBER OF 3-DAY HIGH PRESSURE SYSTEMS OVER THE TENNESSEE VALLEY
JANUARY, 1899 THROUGH JUNE, 1939[17]

| JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 1 | 2 | 2 | 3 | 4 | 4 | 9 | 20 | 9 | 7 | 65 |

valleys in western North Carolina[30], which would be generally applicable to the mountainous regions of east Tennessee, indicated that inversions (due to cold air drainage into valleys from mountain sides) were most frequent in May and October when they occurred from 18 to 22 nights per month and least frequent in August and February when they occurred from 2 to 12 nights per month. Heavy fog (visibility less than 1/4 mile) occurs frequently (Table 20) which limits the solar heating and thus restricts vertical diffusion in the lower layers of air.

TABLE 20

FREQUENCY OF HEAVY FOG(a) [16]
(DAYS PER YEAR)

| | |
|---|---|
| BRISTOL. . . . . . . . . . . . . . | 41 |
| KNOXVILLE. . . . . . . . . . . . . | 18 |
| OAK RIDGE. . . . . . . . . . . . . | 34 |
| CHATTANOOGA. . . . . . . . . . . | 27 |

(a) Visibility less than 1/4 mile.

Above the highest elevations of the Appalachian Mountains, the winds are predominantly westerly throughout the year.[54] At the lower levels the westerlies give way to local wind flow patterns which are generally aligned with the orientation of nearby mountain ranges. The low annual hourly average wind speeds of seven to eight m.p.h. in Knoxville and Chattanooga reflect the obstructing effect of the mountains.

The orographic channeling of the wind flow and the relatively high frequencies of calms in this valley section are strikingly revealed by the seasonal wind roses for Bristol, Knoxville and Chattanooga (Appendix D). Seasonal variations of surface wind direction and speed are largely dependent on the local valley circulation. Such valley stations generally show a lower frequency of strong winds and a higher frequency of calms in contrast to a well exposed, nonvalley type station. A summary of calms for the valley stations of Bristol, Knoxville, and Chattanooga and the more exposed nonvalley station of Smithville is given in Table 21.

During periods of restricted visibility (0-1/2 mile), calms occur 94 to 95 percent of the time at Chattanooga and Knoxville.[32]

It may be concluded that the topography and climatology of the great valley of Tennessee bears a strong influence on the nature and extent of local air pollution problems within the area.

*Cumberland Plateau: Topography and climatology as related to air pollution:* The Cumberland plateau, which includes 5380 square miles, is a tableland with a general elevation of about 2000 feet above sea level, with mountains in the northeastern part rising above the general level to heights of 3500 feet. The eastern boundary is the 800 to 1400-foot escarpment of Walden's Ridge overlooking the valley of east Tennessee; its western boundary is a very irregular escarpment 800 to 1000 feet high, resulting from erosion by streams which rise on its western front. These steep escarpments stand out in such bold relief as to give the name "Cumberland Mountain" to the

TABLE 21

PERCENTAGE OF CALMS FOR THE GREAT VALLEY[31]

| STATION (a) | ANNUAL | WINTER | SPRING | SUMMER | FALL | DAY | NIGHT |
|---|---|---|---|---|---|---|---|
| BRISTOL | 12 | 10 | 10 | 16 | 13 | 5 | 19 |
| KNOXVILLE | 13 | 11 | 11 | 14 | 15 | 6 | 19 |
| CHATTANOOGA | 20 | 14 | 18 | 22 | 27 | 4 | 34 |
| SMITHVILLE | 4 | 2 | 3 | 7 | 4 | 2 | 5 |

(a) All are valley stations except Smithville which is a non-valley station.

entire plateau. In the southcentral part of the plateau is a remarkable valley, Sequatchie Valley. This valley is over 75 miles long in Tennessee and extends 40 miles farther to the south into Alabama. It has an average width of 4 to 6 miles and precipitous walls 800 to 1400 feet higher than the valley floor. The Cumberland plateau is a flat rolling tableland except for the northeastern part which is made up almost entirely of sharp pointed ridges and deep, narrow valleys running in various directions; it is a rough, rugged area. The climate of the plateau differs somewhat from that of the valley of east Tennessee. The average temperatures of January and July are somewhat lower due to the higher altitudes[28]; the rainfall (Figure 7) is generally more abundant, about 55 inches annually[28]; and the average hourly wind speeds are generally higher. While there are no extensive climatological data for this area, the data for Smithville in the highland rim area are indicative if used with discretion. General data on calms for Smithville are given in Table 21; wind roses for Smithville are given in Appendix D.

*Highland Rim: Topography and climatology as related to air pollution:* The highland rim physiographic province, whose eastern border is the foot of the Cumberland plateau, forms an encircling rim around the central basin and is the largest physiographic province of the State with an area of 10,650 square miles. The highland rim province terminates to the west in high ridges overlooking the western Valley of the Tennessee River. The average altitude is slightly less than 1000 feet. From a general topographic standpoint, the highland rim area is a highly dissected plateau, although that portion of the rim immediately west of Cumberland Mountain is a gentle, undulating plain. Its roughest parts are along the edges bordering the central basin, where dissection by streams has formed steep, rounded hills projecting as spurs and isolated remnants far into the basin. The highland rim province is subdivided according to its relation to the central basin, which it encloses, into the eastern, northern, and western highland rims. The eastern highland rim is a gentle plain averaging 1000 feet in altitude and extending from the foot of Cumberland plateau westward to the central basin. The northern highland rim extends from the northern border of the central basin to the Kentucky line and is a region of rugged topography resulting from rather deep stream dissection. West of the central basin, the highland rim is a highly dissected plateau ranging in elevation from 700 to over 1100 feet above sea level. The average altitude is about 900 feet. Its western terminus comprises the hills overlooking the western valley of the Tennessee River.

There are several cities of over 10,000 population in this province. While no major weather station is located in this area, the data for Smithville indicate a relatively low occurrence of calms (4 percent) and a southerly prevailing wind. The climate of this area is primarily dependent on the regional pressure patterns. However, in such a region of hills and valleys, local climates may be varied and, on occasion, the valleys may serve to contain pollutants during certain stable atmospheric conditions.

*Central Basin: Topography and climatology as related to air pollution:* The most conspicuous topographic feature of middle Tennessee is the central or Nashville basin, an oval-shaped depression whose major diameter trends N. 30° E. through Rutherford County, the approximate geographic center of the State. This division (4850 square miles) is one of the most important areas in Tennessee as far as fertility of the soil and density of population are concerned. Its altitude ranges from 500 to 700 feet above sea level. The basin is extremely irregular in outline, as it is entirely surrounded by the irregular highland rim escarpment, 400 or more feet high. Outliers from the highland rim in the form of spurs and isolated remnants extend far out into the basin. In addition to these, the basin is dotted with many small, rounded, residual knobs, rising 200 to 300 feet above the general level.

Generally, the surface of the basin may be considered as gently rolling. The basin is drained by several rivers; the Cumberland and Duck Rivers flow westward in deep, narrow valleys through the highland rim. The general prevailing wind direction is from the south[16], indicating the probable influence of the regional pressure patterns rather than topography. Surface wind roses of Nashville are given in Appendix D. Compared with the valley of eastern Tennessee, the average annual wind speed in this area is generally higher, being 8.5 m.p.h. Average wind speeds vary from 10 m.p.h. in the spring to 7 m.p.h. in the late summer and early fall.

Calms (wind speed 0-3 m.p.h.) average 28 percent of the time, being more frequent in the summer and fall (38 per cent) than in the winter and spring (17 percent).[55] Heavy fog occurs about 11 days out of the year, being more frequent in the last half of the year.[16] During periods of restricted visibility (0-1/2 mile), calms occur 80 percent of the time and the wind is generally from the northwest.[32]

While the annual climatological conditions are generally favorable to the dispersion of pollutants, there are seasonal periods, particularly in the fall, when certain stable atmospheric conditions may lead to local accumulation of pollutants. This condition is observable in a metropolitan area like Nashville when a general smoke pall hangs over the city. Such stable atmospheric conditions are usually associated with low level (nocturnal) inversions which generally "break up" around noon and disperse the pollutants.

*Western Valley: Topography and climatology as related to air pollution:* The Tennessee River, in its northward reflex from Alabama across Tennessee, has carved a narrow, relatively rugged valley and represents a separate physiographic province. The western valley extends from 5 to 10 miles on either side of the Tennessee River from the Alabama State line to the Kentucky boundary--an area of about 800 square miles. The valley itself is relatively narrow and is limited on the east by the higher flat-topped uplands of the western highland rim and on the west, by the Mississippi-Tennessee drainage divide. Much of this valley has now been flooded by Kentucky Lake. The general climatological features of this area are similar to those of the central basin. However, the area does require some special consideration because of local topographical effects on the general weather patterns.

*Plateau slope of West Tennessee: Topography and climatology as related to air pollution:* The plateau slope of western Tennessee, an area of over 9000 square miles, may be visualized as a broad plain whose surface slopes down to the west until it ends abruptly at the bluffs overlooking the flood plains of the Mississippi River. The eastern edge of the plateau is a highly dissected region, described above as the western valley of the Tennessee River; and along this eastern boundary, deep stream dissection has developed a rather rugged topography with altitudes ranging from over 400 to over 700 feet above sea level. From the hills bordering the Tennessee River, the plateau slopes to the west to an altitude of 250 to over 300 feet above sea level along the Mississippi River flood plains. The region is characterized by a rolling topography and general surface forms are the result of stream erosion. At many places small ridges and drainage divides interrupt the regional western slope of the topography. Gullies and ravines form rapidly on the hill slopes and in many places a pronounced "badland" topography has developed.

Climatic conditions of this province are generally favorable to the dispersion of pollutants. The prevailing wind is from the south,[16] showing the general influence of the regional pressure pattern. The average annual wind speed at Memphis is 10 m.p.h.

Percent of calms (0-3 m.p.h.) varies from 13 at Memphis to 22 at Chesterfield, and 28 at Dyersburg. Calms are most frequent in the summer and fall and least frequent in the winter and spring. Wind roses are shown in Appendix D. No data were found available on inversions or lapse rates, but, in Memphis, heavy fog occurs only five days per year.[16] During periods of restricted visibility (0-1/2 miles), calms occur 61 percent of the time and the wind is generally from the northwest to northeast sector.[32]

*Mississippi Alluvial Plain: Topography and climatology as related to air pollution:* The narrow, frequently marshy land, extending from the Mississippi River bluffs on the east to the Mississippi River on the west, is the most western physiographic province of the State and is commonly called the Mississippi River Bottoms. It covers nearly 800 square miles, much of which is dotted by numerous lakes and marshes. Where cultivated, the soils are of great fertility. Its average altitude is less than 300 feet above sea level and many parts of the area are below high-water mark of the Mississippi River. The climate of this area is not much different from that of the plateau slope of west Tennessee.

### Summary of Topography and Climatology as Related to Air Pollution

The climatological and topographical conditions affecting air pollution potential vary considerably throughout the State. (Selected data in Table 21 depict the general climatological pattern of the State.) In progressing eastward from the plateau slope of west Tennessee to the valley of east Tennessee, there are evident dissimilarities among the various station climates; the surface wind direction apparently comes more under the influence of the local topography, the percentage of calms increases, the percentage of total possible sunshine decreases, the number of days with fog increases, the occurrence of restricted visibility (0-1/2 mile) increases, and the occurrence of stable conditions (nocturnal inversions) in the lower layers of the atmosphere appear to increase. Based on this study of the climatology and topography of the State, it may be generally concluded that conditions for atmospheric dispersion of pollutants are favorable in western Tennessee, moderately favorable in central Tennessee, and least favorable in the eastern part of the State.

## AIR POLLUTION STUDIES

As there are no State laws or regulations pertaining specifically to air pollution, State activity in this field has been very limited. The Industrial Hygiene Service of the Tennessee Department of Public Health has made one air sampling survey (near an electrometallurgical plant in Chattanooga) and has given some consultation to municipalities when requested.

Four municipalities in the State have conducted air sampling at one time or another: Chattanooga, Kingsport, Knoxville, and Nashville. Chattanooga has been collecting dustfall data since 1935 and has recently made some determinations by high-volume sampler and electrostatic precipitator. Kingsport conducted some air sampling from about 1952 to 1953. Knoxville made dustfall studies from 1927 to 1951. Nashville conducted a dustfall sampling program during 1937 through 1939. These programs are considered in somewhat more detail in the regional and local area discussions presented later. Local officials, cooperating in the National Air Sampling Network of the U. S. Public Health Service, have collected samples in Chattanooga since 1954, and in Nashville and Knoxville since January 1957. The samples are analyzed at the Public Health Service's Sanitary Engineering Center. In addition, the Bristol Chamber of Commerce had personnel from the Coal Producers' Committee for Smoke Abatement visit the city, make an inspection of industrial, commercial, public and church boiler plants and firing procedures and make recommendations for reducing smoke emissions.

Two universities have done some air sampling and other work on air pollution. The University of Chattanooga carried out air sampling and analysis in Chattanooga for one year for an electrometallurgical plant in the city. The University of Tennessee at Knoxville has done extensive work on atmospheric fluorides, including air sampling in Maury and Blount Counties. This work has been sponsored by several companies.

The Tennessee Valley Authority has been active in evaluating air pollution around its power plant installations.[33] Studies have been planned and conducted in each steam plant area on a preoperational and postoperational basis. During the preoperational period, meteorological data are collected and samples from selected species of trees are collected and analyzed. After the plant goes into operation, studies include meteorological observations, analysis of plant operation, routine monitoring of sulfur dioxide, using Thomas Autometers, sampling and analysis of plant foliage and special studies on dispersion, including measurements of sulfur dioxide and observation of fly-ash control. Inasmuch as all large TVA steam plants are located in rural areas (with the possible exception of the Kingston plant), the principal biological study has been directed toward possible effects on vegetation. No significant elevation of sulfate has been detected in conifers. Concentrations observed in the foliage of sampled deciduous trees very near the Johnsonville plant have been below injurious levels. In addition, the TVA is conducting a research program aimed at developing a practical and economically feasible method of removing sulfur dioxide from flue gases and converting it into a useful, saleable product.

Considerable air monitoring for radioactivity is being carried out in the Oak Ridge area in connection with the Atomic Energy Commission's plants (operated by Carbide and Carbon Co.). No results of this monitoring were made available, but it was reported that radiation levels found are not dangerous.

Some air quality measurement has been made by industrial plants. Those known to have done such work are a phosphate company (measurement of fluorides in Maury County); a chemical plant (measurement of particulate matter in Memphis); and a paper company (stack sampling in Kingsport).

From the foregoing discussion.[34] it is concluded that very little information is available regarding ambient air pollution or emission measurements in Tennessee. This is a field in which the State might well render aid, either by doing actual field measurements of air quality, or by making available technical assistance, sampling equipment, or laboratory facilities for analyzing samples.

## SUMMARY OF RESPONSE TO QUESTIONNAIRES

Although the limitations of securing information by questionnaire are well recognized, and although the jurisdictional area of a local health department is so large that respondents may not be aware of all existing problems, it is deemed of value to present a summary of the responses to questionnaires. This information is presented to provide, "in a nutshell," an over-all summary of air pollution in the State, and should be so understood. The jurisdictional basis for the summary (Table 22) is the local health department which may serve one or more counties. From these data certain generalizations are made:

1. Air pollution is more closely associated with urban areas than rural areas.

2. People in urban areas are more apt to tolerate air pollution than those in rural areas.

3. Problems considered minor in urban areas may well be considered major in a rural area.

## TABLE 22

### SUMMARY OF RESPONSE TO QUESTIONNAIRES

(PERCENT OF JURISDICTIONS ANSWERING YES TO QUESTION, EXCEPT THE LAST LINE OF THE TABLE.)

| QUESTION | ALL AREAS (a) | URBAN AREA (a) | RURAL AREA (a) |
|---|---|---|---|
| ARE THERE ANY OPERATIONS (MUNICIPAL, DOMESTIC INDUSTRIAL) IN YOUR AREA OF JURISDICTION THAT EMIT OBJECTIONABLE AMOUNTS OF SMOKE, FUMES, DUST OR ODOR TO THE ATMOSPHERE? | 63 | 92 | 44 |
| IN YOUR OPINION ARE THESE POLLUTENTS PRESENT IN SUFFICIENT CONCENTRATIONS TO CAUSE: | | | |
| A. DISCOMFORT OR INCONVENIENCE TO RESIDENTS? | 57 | 85 | 39 |
| B. DAMAGE TO PROPERTY? (AUTOS, PAINT, CLOTHING, BUILDINGS, ETC.) | 19 | 31 | 12 |
| C. DAMAGE TO VEGETATION? | 7 | 15 | 2 |
| D. INJURY TO ANIMAL LIFE? | 4 | 4 | 5 |
| HAS YOUR OFFICE RECEIVED COMPLAINTS CONCERNING AIR POLLUTION DURING THE PAST TWO YEARS? | 46 | 62 | 37 |
| ARE THE AIR POLLUTION PROBLEMS IN YOUR AREA OF JURISDICTION PRINCIPALLY DUE TO: | | | |
| A. MUNICIPAL ACTIVITIES (DUMPS, INCINERATORS, ETC.) | 25 | 23 | 27 |
| B. DOMESTIC ACTIVITIES (INCINERATORS, HEATING PLANTS, ETC.) | 7 | 19 | 0 |
| C. COMMERCIAL ACTIVITIES? | 15 | 23 | 10 |
| D. INDUSTRIAL ACTIVITIES? | 51 | 81 | 32 |
| IN YOUR OPINION ARE THE PROBLEMS: | | | |
| A. OF MAJOR SIGNIFICANCE? | 18 | 11 | 22 |
| B. OF MINOR SIGNIFICANCE? | 45 | 81 | 22 |
| ARE THERE ANY LOCAL ORDINANCES OR REGULATIONS FOR THE CONTROL OF SMOKE, FUMES, DUST OR ODOR? | 22 | 35 | 15 |
| HAVE ANY STEPS BEEN TAKEN IN YOUR AREA OF JURISDICTION TO CONTROL SOURCES OF AIR POLLUTION? | 37 | 62 | 22 |
| ARE THERE SOURCES OF AIR POLLUTION OUTSIDE YOUR AREA OF JURISDICTION WHICH HAVE CREATED A PROBLEM IN YOUR AREA? | 13 | 15 | 5 |
| NUMBER OF JURISDICTIONS ARE: | 67 | 26 | 41 |

(a) An "area" is the jurisdictional area of a county or district (multi-county) health department.

An "urban area" is an "area" which contains either a city with over 10,000 population or a county with over 30,000 people.

A "rural area" is an "area" that does not meet the criteria for an "urban area."

4. Problems associated with industry and domestic activities are more prevalent in urban areas where there are greater concentrations of people and industry.

5. Problems associated with refuse disposal are more common in less populated areas where refuse is more often disposed of on open dumps.

## AIR POLLUTION PROBLEMS

### Air Pollution Problems of Major Concern

There are 12 areas (See Note (a) in Table 22) in the State in which air pollution problems were reported by local officials to be of major significance. These areas, with indicated major problems, are Davidson (community-wide problem in Nashville due mainly to soft coal combustion and industrial emissions); Maury (emissions from phosphate industry); Hamilton (community-wide problem in Chattanooga due mainly to industrial emissions and soft coal combustion); Cheatham (dump); Benton (dump); Hardeman (cotton gins, dump); Henderson (smoke); Haywood (cotton gins, dump); Henry (dust); Obion (odors); Polk (sulfur dioxide); and Loudon (dump).

In addition, there are about eight other areas which bear particular surveillance but in which local officials felt inclined to rate their air pollution problems as not being of major significance. These areas are Knox (community-wide problem in Knoxville due mostly to soft coal combustion); Shelby (many localized nuisance problems but apparently no community-wide problem in Memphis); Dyer (lint from cotton gins); Blount (past problem due to fluoride emissions); Carter (odor problem from hydrogen sulfide); Hamblen (smoke and odor problems in Morristown); Sullivan (coal smoke in Bristol and Kingsport); and Roane (potential problems from AEC, TVA, and an electrometallurgical operation).

### Interjurisdictional Air Pollution Problems

Eight areas of the State reported the presence of air pollution problems where the offending source was in another political jurisdiction. Sumner County reported an odor problem from a rayon plant in Davidson County. Nashville reported problems from industry located just outside the city in Davidson County. Dyer County reported pollutants from sources in an adjoining county. Chattanooga reported pollutants from industrial sources outside the city in Hamilton County and also from Rossville, Georgia, across the State line. On the other hand, residents in Hamilton County reported pollution from the city of Chattanooga. Cleveland reported an odor problem from a paper mill located in an adjoining county. Wilson County reported an odor problem at certain times of the year from a rayon plant located in Davidson County. Henderson County also reported an unspecified interjurisdictional problem.

In the larger communities it is probable that other interjurisdictional problems exist which have not been specifically recognized by local officials because no particular major source of pollution is involved. Rather, the problems involve interchange of air bearing more uniformly dispersed pollutants.

Some means of bringing about an equitable solution to problems of an interjurisdictional nature should be provided for by the State.

### Other Air Pollution Problem Areas

There are some 20 additional areas in the State which experience air pollution problems of a relatively minor nature. These areas, together with type of problem are:

Putnam (odor from sewage; industrial dust)
Rutherford (coal smoke; industrial odor and dust)
Bedford (smoke and sawdust)
Madison (dump; industrial smoke)
Tipton (cotton gins; odors)
Gibson (cotton gins)
Bradley (dump; odor from industry)
McMinn (odor from paper mill)
Anderson (smoke)
Washington (smoke and dust)
Campbell (dump)
Greene (smoke)
White (dump)
Coffee-Franklin (dump)
Cumberland (odor from sewage)
Williamson (dump; industrial smoke and odor)
Hickman-Perry (mining dusts)
Lauderdale (gins)
Weakley (mining dusts)
Monroe (dump; industrial smoke and odor)
Sevier (industrial smoke)

These areas are geographically widespread. While their pollution problems are relatively minor, they do constitute unwanted nuisances.

### Types of Major Air Pollution Problems

*Community-wide air pollution problems:* In the major urban areas of Nashville, Knoxville, and Chattanooga there are air pollution problems which affect a substantial proportion of the residents. The cauldron of pollution over these cities arises from a multitude of sources but presumably may be largely attributed to the combustion of soft coal (residential, public, commercial, and industrial) and the great variety and quantity of industrial emissions. There is no doubt that the pollution from coal combustion has been decreasing, but increasing population, industrial activity, and automobile traffic indicate that the air pollution problem will remain and perhaps grow more severe unless some abatement program in initiated.

*Air pollution damage to agriculture:* Damage to agriculture has been reported in several areas of Tennessee. A classic example of denudation of vegetation is the well-known Ducktown area of Polk County, in the extreme southeastern corner of Tennessee. This region is the largest producer of copper east of the Mississippi River. The production of copper is restricted to a mountain valley, about six miles long and about four miles wide. A century ago, it was thickly forested. The copper deposits were opened in 1847. Two or three years later, smelters were built in the area; the copper was separated by roasting it in open pits, allowing the sulfur to burn off as sulfur dioxide and escape into the air. Ten or fifteen years after the Civil War a railroad was built to Ducktown, making coke and modern machinery available. Production was increased to 15 to 20 million pounds a year. For a number of years, 40 tons of sulfur poured out into the air every day. Soon the trees and grass were killed by the pollutants, and for miles around, no sprig of living green was to be found in the Ducktown basin.[35] In 1905 the State of Georgia filed a bill in equity in the U. S. Supreme Court to enjoin two copper smelters from discharging noxious gases, which were passing across the state line from Tennessee into Georgia. The injunction was granted in what is, perhaps, the earliest well-known case of interstate pollution. Today, the oxides of sulfur produced in roasting the copper ore are manufactured into sulfuric acid, having greater value than the copper itself.

During recent years, farmers in two widely separated Tennessee counties have complained that atmospheric emissions from certain industrial operations have caused detrimental effects on nearby plant and animal life. These counties are Blount and Maury and the pollutant is a fluoride. The University of Tennessee Agricultural Experiment Station has done extensive work on these fluoride problems.[36,37,38]

The fluoride problem in Blount County purportedly involves a single operation--the manufacture of aluminum

(aluminum reduction). Prior to World War II, fluoric emissions from the cryolite in electrolitic cells had not been great enough to cause observable effects on plant and animal life in the locale. During the war, the production of aluminum was expanded. In recent years, farmers in this area have contended that livestock has suffered injurious effects from ingestion of locally grown forage. From studies conducted by the University, it was concluded that: "The fluorine emissions from the aluminum manufacture occur as hydrofluoric acid, and that compound is deemed causal to the contamination of forage crops in certain locales in Blount County...."[39] The company involved has recently installed controls on fluoride emissions, and the general feeling of many concerned is that the problem is under control. In addition, this company runs a sampling program, has bought extensive land around the plant, and supports research work at the University of Tennessee and other institutions on fluoride problems.

"The fluorine problem in Maury County involves several manufacturing operations that are purported to be responsible for present conditions. Admittedly, however, emissions of fluorine occur when rock phosphate is either acidulated to produce superphosphate, calcined to produce fused tricalcium phosphate, sintered to produce material suitable for furnace burden, and through the thermal processing of electric furnace slag into glass wool. Now, however, farmers are contending that the several nearby manufacturing operations emit atmospheric effluents that cause abnormal occurrences of fluorine in locally-grown forage crops. At times, the fluoric evolutions and concomitant aerosols in Maury County operations have been so copious and discernible as to be registered distinctly in photographs. The difference between the quantity of fluorine present in a furnace charge of rock phosphate before and after its thermal processing may represent a daily emission of two tons of fluorine per day in the form of hydrofluoric acid. Happily, such emissions now are being minimized through their capture by means of adsorbents. In absence of fluoric dusts and without mechanical pollution from phosphatic soils, it seems obvious that fluoric contamination of forage vegetation in Maury County has come directly from the fluoric effluents present in the atmosphere, rather than through uptakes of fluorides from the soil."[39]

The concern with fluorides in the case of forages is not with damage to the vegetation (forage) since, except in extremes, this does not occur; but rather with the damage to the consumer of the forage (cattle).

There are a few other vegetation damage problems of localized nature in several additional areas of the State. These include emissions from fertilizer plants that acidulate rock phosphate and release fluorine to the atmosphere, dust from cement, lime, and brick manufacturers, and others.

*Air pollution from cotton ginning:* Problems of lint and smoke from cotton ginning operations are widespread throughout western Tennessee. These operations result in localized nuisance problems which, in many cases, are quite severe. The problem is seasonal, occurring only in the fall of the year.

*Air pollution from disposal of wood wastes:* Burning and other handling of the large amounts of wood wastes from lumber and furniture companies result in the release of large amounts of sawdust, fly-ash, and smoke to the air, creating a localized nuisance problem. This problem is prevalent in several Tennessee cities, particularly Memphis and Morristown.

*Other types of major air pollution problems:* Certain other industrial operations have been widely reported as major air pollution problems. Those cited are odors from paper mills and rayon plants, dusts from certain mining operations (mainly in middle and west Tennessee) and cement plants, and fumes from foundries and electrometallurgical plants.

## AIR POLLUTION ORDINANCES AND CONTROL PROGRAMS

There are seven cities in Tennessee with specific air pollution control ordinances. These are Chattanooga, Dyersburg, Jackson, Kingsport, Knoxville, Memphis, and Nashville. There are other legal provisions in nuisance regulations, building codes, zoning laws and elsewhere which deal with air pollution control more or less directly but discussion of them in this report is not warranted. The salient features of presently existing ordinances are given in Table 23.

In general, the ordinances of Chattanooga and Knoxville contain authorization for a comprehensive air pollution abatement and regulatory program, except that the Chattanooga ordinance has no fly-ash limitation clause. The ordinances of Kingsport and Nashville authorize a rather extensive abatement and regulatory activity. The principal feature lacking is approval of plans, or registration of installations which may cause pollution, other than combustion devices. Authority is given to abate nuisances arising from both combustion and other processes. The ordinance in Nashville provides for regulation of fuel use not provided in the Kingsport ordinance.

The Memphis ordinance is designed to extend needed control of smoke from combustion processes. It does not provide for regulation nor abatement of installations or emissions from other processes. The smoke emission limit of Ringelmann number 3 is higher than that of most cities.

The Dyersburg and Jackson ordinances provide a means of prosecuting parties responsible for emission of dense smoke. No authority is given to regulate fuel-burning or other devices or fuels. It is likely that such ordinances are all that can reasonably be enforced (for financial reasons) by those smaller communities.

There are seven municipalities in the State that have an official air pollution control activity and one city, Bristol, with an unofficial activity. The customary activities of local health departments in abating nuisances will not be considered in detail here. In the larger urban areas and in some of the smaller cities, e.g., Columbia, the health departments have done and are doing considerable work in alleviating air pollution problems of the nuisance type. in other areas of the State, little or nothing is done in this field.

Memphis has a smoke inspector and some steps have been taken to control sources of pollution, mainly through review of plans for proposed installations. Generally, Memphis does little toward abating local nuisance problems beyond limited complaint investigations.

Jackson's ordinance "to prohibit the emission of cinders, dust, fly-ash, fumes and gases" is enforced by the police department. The police department restricts its operation to complaint investigations, of which it reportedly receives very few.

Dyersburg's smoke ordinance is enforced by the fire department. There is reportedly very little enforcement of the ordinance, although in the past the fire chief has made some smoke density determinations and has investigated complaints.

Nashville has a smoke inspector who carries on a necessarily limited program of control. This program involves both inspection of firing equipment and citation of flagrant smoke emitters. While the inspector does a commendable job, a one-man staff cannot carry on an adequate program to cope with Nashville's problem.

Chattanooga's air pollution control program is carried on by a board and a bureau. The board consists of volunteer lay citizens. This board sets policy, hires staff for the bureau, etc. The actual field and control work is carried out by the air pollution control bureau, with a contemplated staff consisting of

## TABLE 23

## SALIENT FEATURES OF AIR POLLUTION CONTROL ORDINANCES

| City | Prohibited emissions | Boards |  | Regulate sale of equip. | Plan approval |  | Collect fees | Rule-making authority | Permits |  | Periodic inspections | Other provisions | Fuel regulations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Appeal | Advisory |  | Combustion devices | Other devices |  |  | Installation | Operating |  |  |  |
| Chattanooga | Smoke equal to or darker than #2 Ringelmann.(b)<br>Nuisance emissions—requirements vary with nature of location and past land use. | Yes(a) | Yes(a) | No | Yes | Yes | Yes | Yes (For certain purposes) | Yes | No | Boilers may be inspected if not inspected by the State within the past 14 months. | Require mechanical firing, low volatile coal or other smokeless fuel in certain cases. Smoke-consuming devices reqd. on locomotives. | Coal of less than 23% volatile must be used in all new & replacement units not having mechanical firing; one-and two-family dwellings excepted. |
| Dyersburg | Smoke equal to or darker than #2 Ringelmann.(b)<br>Emissions which cause a nuisance. | No | No | No | No | No | No | No | No | No | No |  | No |
| Jackson | Emissions from combustion devices which create a nuisance. | No | No | No | No | No | No | No | No | No | No |  | No |
| Kingsport | Smoke equal to or darker than #2 Ringelmann (b); special provision for locomotives.<br>Fly-ash from combustion processes in excess of 0.35 grains/cu. ft. at 350°F. and 50% excess air, when coal is burned wholly or partly in suspension.<br>Emissions which cause a nuisance. | Yes | No | No | Yes | No | Yes | Yes (Fairly broad powers) | Yes Combustion Equipment only. | Yes Combustion Equipment only | No | Smokeless solid fuel or diesel engines required on locomotives. Certain exceptions for road engines. | No |
| Knoxville | Smoke equal to or greater than #2 Ringelmann; one-and two-family dwellings excepted (b).<br>Emissions which create a nuisance. Requirements vary with nature of location and past land use. | Yes(a) | Yes(a) | Yes | Yes | Yes | Yes | No | Yes | Yes (initial, after construction or alteration) | Boilers may be inspected twice per year if not inspected annually by insurance, railway or I.C.C. (locomotive) inspectors. | Require mechanical firing, low volatile coal or other smokeless fuel in most cases; one-and two-family dwellings excepted.<br>Smoke indicators reqd. in certain cases.<br>Extensive standards for combustion equipment.<br>Acceptable flyash collectors reqd. on pulverized coal burning plants. | Requirements that "certain specified fuels" be used in certain instances. |
| Memphis | Smoke equal to or darker than #3 Ringelmann.(b)<br>Emissions which are injurious to health or property. | No | Yes | No | Yes | No | Yes | No | Yes Combustion Equipment only. | No | No | Mechanical firing reqd. in certain cases. Over-fire steam air jets reqd. in certain cases.<br>Extensive standards for combustion equipment. | Portable boilers must use coke or other smokeless fuel. |
| Nashville | Smoke equal to or darker than #2 Ringelmann; special provisions for locomotives; residences of 3 families or less excepted(b).<br>Fly-ash from combustion processes in excess of 0.75 grains/cu.ft. at 500°F.and 50% excess air, of which not to exceed 0.20 grains/cu. ft. shall be retained on a 325 mesh sieve.(c)<br>Emissions which create a nuisance.(c) | Yes | No | Yes | Yes | No | Yes | Yes (For certain purposes) | Yes Combustion Equipment only. | Yes Combustion Equipment only. | Yes All combustion equipment except gas or oil fired and certain few others.(c) | Railroads required to use mechanical firing of smokeless fuel.<br>Smoke indicators required on certain larger units.<br>Extensive standards for stoker construction. | Coal of 23% or less volatile must be used unless unit has mechanical firing. Does not apply to dwellings of three families or less and downdraft furnaces. |

(a) One board serves both purposes.
(b) Certain exceptions made for times when a fire is being cleaned or started.
(c) Residences of three families or less excepted.

a director, several inspectors, and secretarial help. The current staff consists of two inspectors who carry on a program of control. While over the years this program has made considerable progress, particularly in the smoke control field, its current resources are inadequate for the magnitude of Chattanooga's pollution problem.

Knoxville has two smoke regulation engineers to carry on its smoke abatement program. These personnel have, in addition to their smoke inspection work, responsibility for inspection of boilers and all new gas-fired installations. These additional duties require most of their time, with the practical result that little is done in the smoke abatement field. The local program has achieved results in the past but is reported to be inadequate for the present needed activity.

Kingsport's air pollution ordinance set up a separate division of air pollution control under a director. The air pollution program of the city did much to improve the air quality of Kingsport, reducing pollution from both soft coal combustion and from industry. Since the recent resignation of the air pollution control director, the program has fallen to the building inspector in addition to his regular duties.

Bristol has no ordinances or governmental body regulating air pollution. However, the Chamber of Commerce has been very active in the smoke abatement field, carrying on a voluntary abatement program. This has been largely a matter of educating firemen and instilling civic pride. It is reported that they have done much good, but there still remains a considerable problem to be overcome.

## RESOURCES AVAILABLE FOR RESEARCH AND INVESTIGATION

The University of Tennessee, at Knoxville, and the University of Chattanooga have staff members who are particularly competent in various aspects of air pollution investigation because of their past participation in field and/or research studies. The University of Tennessee also has an engineering experiment station which could develop a program for air pollution studies, although no work has been done to date. Vanderbilt University, at Nashville, and the University of Tennessee, at Memphis, have medical schools which could develop a program on the health aspects of air pollution.

The Industrial Hygiene Service of the State Department of Public Health has excellent laboratory equipment and facilities which could also be used in developing a State program in air pollution, if desired, but it does not have adequate staff to handle such a program.

Meteorological and climatological data useful in studying pollution dispersion are available from a number of U. S. Weather Bureau stations throughout the State, (Figure 8).

# DISCUSSION OF AIR POLLUTION ON A REGIONAL AND LOCAL AREA BASIS

## DEFINITION OF THE REGIONS

For the purpose of a detailed examination of air pollution problems and potential problems, the State is divided into five regions, corresponding generally to the topographic provinces discussed previously. These regions are shown in Figure 10.

## AIR POLLUTION IN REGION I

Topographically, this area may be visualized as a broad plain characterized by a rolling surface. There are not the high mountains, deep valleys, hills, bowls, and other topographic features which tend to retard the dispersion of pollutants. The prevailing winds are southerly throughout most of the year, and the average annual hourly wind speed is about 10 m.p.h. Calms average about 20 percent. Average annual precipitation is about 50 inches, and days of heavy fog are few, around six per year.[16] While the possibility of climatic conditions leading to atmospheric stagnation cannot be ruled out, it would appear that the combined topographic-climatic conditions are generally favorable to the dispersion of pollutants.

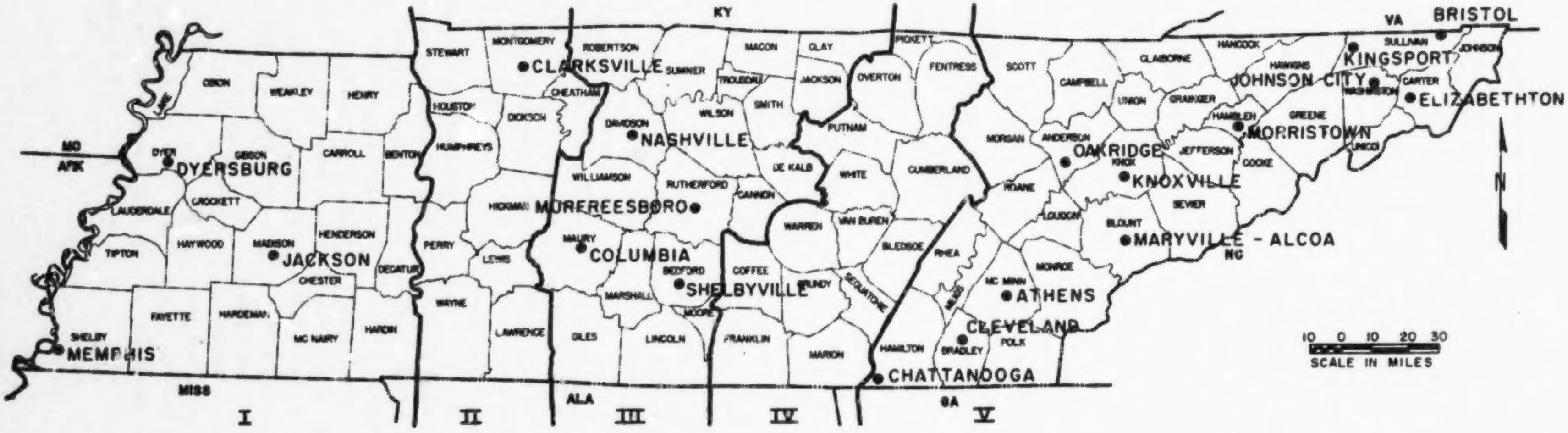
Of a total population in this region of approximately one million (est. 1955), 53 percent live in Shelby County (includes Memphis). This is also the industrial center of the area, accounting for two-thirds of the manufacturing employees. Three counties (Shelby, Gibson, and Madison) in this 21-county area have over 80 percent of all manufacturing employment. Leading industries are lumber, and wood products, food products, textile, apparel, furniture, machinery and chemicals. Primary fuel used in the urban areas of this region is natural gas. Use of coal is correspondingly limited.

Consideration of the combination of favorable topographic-climatic conditions, the limited use of coal, and the type and location of industry in this area leads to the general expectation that air pollution problems will be of a localized type and not of a general community-wide nature.

TABLE 24

SELECTED CLIMATOLOGICAL DATA FOR MEMPHIS. 1949-1954[40,16]

| MONTH | DEGREE DAYS | PRECIPITATION | MEAN HOURLY WIND SPEED (M.P.H) | PREVAILING WIND DIRECTION | PERCENT CALMS | PERCENT POSSIBLE SUNSHINE | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|---|---|
| JANUARY | 725 | 5.6 | 12.4 | S | 5 | 45 | 1 |
| FEBRUARY | 591 | 4.7 | 11.7 | S | 8 | 52 | 1 |
| MARCH | 427 | 5.6 | 12.4 | S | 6 | 58 | 1 |
| APRIL | 139 | 4.8 | 11.8 | S | 6 | 64 | - |
| MAY | 24 | 3.9 | 9.4 | S | 15 | 69 | - |
| JUNE | 0 | 3.3 | 8.4 | S | 12 | 74 | - |
| JULY | 0 | 3.2 | 8.0 | S | 15 | 73 | - |
| AUGUST | 0 | 2.9 | 7.5 | NE | 25 | 73 | - |
| SEPTEMBER | 17 | 2.6 | 8.3 | NE | 15 | 71 | - |
| OCTOBER | 126 | 3.3 | 8.4 | S | 22 | 69 | - |
| NOVEMBER | 432 | 4.6 | 10.3 | S | 16 | 58 | 1 |
| DECEMBER | 673 | 5.1 | 10.8 | S | 9 | 45 | 1 |
| YEAR | 3,137 | 49.6 | 10.0 | S | 13 | 64 | 5 |


KY
VA
BRISTOL
MO
ARK
MISS
ALA
GA
NC
I
II
III
IV
V
MEMPHIS
DYERSBURG
JACKSON
CLARKSVILLE
NASHVILLE
MURFREESBORO
COLUMBIA
SHELBYVILLE
CHATTANOOGA
CLEVELAND
ATHENS
OAKRIDGE
KNOXVILLE
MARYVILLE - ALCOA
MORRISTOWN
JOHNSON CITY
KINGSPORT
ELIZABETHTON
SHELBY
TIPTON
LAUDERDALE
DYER
OBION
LAKE
WEAKLEY
HENRY
GIBSON
CROCKETT
HAYWOOD
FAYETTE
HARDEMAN
MADISON
CHESTER
HENDERSON
CARROLL
BENTON
DECATUR
MC NAIRY
HARDIN
STEWART
HOUSTON
HUMPHREYS
PERRY
WAYNE
MONTGOMERY
DICKSON
HICKMAN
LEWIS
LAWRENCE
CHEATHAM
ROBERTSON
SUMNER
DAVIDSON
WILLIAMSON
MAURY
GILES
MARSHALL
RUTHERFORD
BEDFORD
LINCOLN
MOORE
TROUSDALE
WILSON
SMITH
MACON
CLAY
JACKSON
DE KALB
CANNON
COFFEE
FRANKLIN
GRUNDY
WARREN
VAN BUREN
WHITE
PUTNAM
OVERTON
PICKETT
FENTRESS
CUMBERLAND
BLEDSOE
SEQUATCHIE
MARION
HAMILTON
RHEA
MEIGS
BRADLEY
POLK
MC MINN
MONROE
ROANE
MORGAN
SCOTT
CAMPBELL
ANDERSON
UNION
CLAIBORNE
GRAINGER
KNOX
LOUDON
BLOUNT
SEVIER
JEFFERSON
HAMBLEN
COCKE
HANCOCK
HAWKINS
GREENE
SULLIVAN
WASHINGTON
CARTER
UNICOI
JOHNSON
N
10 0 10 20 30
SCALE IN MILES

DIVISION OF STATE FOR REGIONAL DISCUSSION

FIGURE 10

There are three cities in this area with over 10,000 population; they are Memphis, Jackson, and Dyersburg.

### Memphis

Memphis is located on a bluff overlooking the Mississippi River. The city is situated on relatively level land and climatic conditions appear favorable for dispersing atmospheric pollutants. Selected climatological data taken at the Memphis Airport are given in Table 24, and wind roses are given in Appendix D.

Population estimates for Memphis and Shelby County indicate a substantial growth (Table 25). This county has a great diversity in the manufacturing field. Of a total estimated nonagricultural employment of 135,000[41], 38,000 were employed in manufacturing and 97,000 in nonmanufacturing. Larger manufacturing industries are food, lumber, furniture, printing, chemicals (including vegetable and animal oils), fabricated metals, and machinery. Employment data are given in Appendix C. Industrial emissions include odors from vegetable oil producers, chemical, rubber, food and asphalt companies; nitrogen oxides and sulfur dioxide gases; smoke from boilers, cupolas, and lumber and furniture companies; dusts from cement, sand blasting, insecticide, feed and milling companies; and fluorides, phosphoric acid, chlorinated hydrocarbons, cotton lint, cupola emissions, lead and lead oxide, silica, ferro-silica and chrome, calcium arsenate, and sawdust. The city, in developing the Presidents Island area, is bidding for the location of new industry in the Memphis area.

TABLE 25

POPULATION - MEMPHIS AND SHELBY COUNTY[1,3,5]

| YEAR | SHELBY COUNTY | MEMPHIS | REST OF COUNTY |
|---|---|---|---|
| 1940 | 358,250 | 292,942 | 65,308 |
| 1950 | 482,393 | 396,000 | 86,393 |
| 1955 | 530,140 | 435,722 | 94,418 |
| 1960 | 590,959 | 486,064 | 104,895 |
| 1965 | 649,543 | 534,639 | 114,904 |
| 2000 | 750,000 | • | • |

The major fuel used in this area is natural gas. In 1956, 43,753,898,000 cu. ft. were used and distributed as follows: 13.2 billion, residential; 9.5 billion, commercial; 20.3 billion, industrial; 0.8 billion, other. Consumption of other fuels is unknown but is relatively small. Although Memphis is currently served by TVA power, a municipal power plant is being constructed and is expected to be in operation in 1958. This plant will use natural gas during the summer months and coal the rest of the year. Annual coal consumption has been estimated at a million tons. Refuse is disposed of in sanitary land fills, thus excluding pollution from that operation; back yard incineration is very limited.

The 191,235 motor vehicles registered in Shelby County are estimated to consume 159 million gallons of gasoline per year. The 24-hour annual average traffic flow into and out of the city of Memphis is 130,000 vehicles. In addition to automotive exhaust, there are exhaust fumes from local bus lines and from the nine railroad lines (all diesel) serving the city. The city is served by 88 motor freight lines, 10 bus lines, 5 barge lines, and 13 national highways.

No sources of pollution involving interjurisdictional areas were reported. Occasionally, dust brought in from the "Texas Dust Bowl" is deposited over Memphis. Some apprehension regarding radioactive fall-out has been expressed by a few residents.

Certain operations in the Memphis area emit objectionable amounts of pollutants to the air in sufficient quantities to cause discomfort or inconvenience to residents in limited areas and, very occasionally, cause damage to property. Complaints concerning localized pollution problems have been received. These complaints have concerned odors, smoke, sawdust, lacquer and paint from lumber and furniture industries, and odor from the oil mills. In general, air pollution problems are attributed to industrial sources, are local in nature, and are considered of minor significance.

There is a smoke ordinance and a smoke inspector; and other steps have been taken to control sources of pollution, mainly by review of plans for proposed plants and industries. The city of Memphis is scheduled to participate in the U. S. Public Health Service's National Air Sampling Network in 1958.

### Jackson

Jackson, with a population of 31,600 in 1955, is located near the center of Madison County on gently rolling terrain. Climatic conditions are similar to those in Memphis and appear favorable for dispersing atmospheric pollutants. The prevailing wind is from the south.

Population estimates predict a continued growth of about 34 percent in all of Madison County from 1955 to the year 2000, and an increase of 14 percent in Madison County from 1955 to 1965.

Manufacturing employment in Madison County is estimated at about 3585 for 1956. The larger industries are food, textiles, and lumber. Industrial emissions include odors and dusts from several sources.

Principal fuel used in this area is gas. For the year 1956, 1,858,224,000 cubic feet were consumed. Annual coal usage is estimated at 13,000 tons. Little fuel oil is used.

Refuse is disposed of on a land fill where, in the past, it had been burned, producing smoke and odor. More efficient operation of the fill has recently reduced this problem.

Motor vehicle registrations for Madison County for 1956 were 20,449. These vehicles consumed an estimated 17,000,000 gallons of gasoline. The city is served by three railroads (all diesel-powered), two Federal highways, and four common carriers. Pollution from transportation sources does not appear to be a great problem.

No pollution from natural sources or from an extrajurisdictional area was reported.

There are operations in the Jackson area which emit objectionable amounts of pollutants to the air and cause discomfort or inconvenience to residents in limited areas. A few complaints concerning air pollution have been received. They have concerned smoke and odor from burning refuse, both at the dump and, to a limited extent, in back yards, and smoke from wood waste disposal at a lumber company. Generally, air pollution problems are local in nature and are considered of minor significance.

There is a local ordinance to prohibit the "emission of cinders, dust, fly-ash, fumes, and gases," enforced by the police department. The department restricts its operation to complaint investigation and has indicated that it receives very few complaints.

### Dyersburg

Dyersburg, in Dyer County, had a population of 32,900 in 1955 and is located on rolling ground, adjacent to the lowlands of the Mississippi River. Prevailing wind is southerly, with calms (0-3 m.p.h.) prevalent about 28 percent of the time. Topographic-climatic conditions are similar to those in Memphis and appear generally favorable for dispersing pollutants.

Population estimates indicate a low growth rate, only 2.7 percent between 1950 and 1965. The city of Dyersburg is expected to gain at the expense of the rest of the county.

Industrial manufacturing employment for 1956 was approximately 1210, with food, textiles, apparel, and lumber industries predominating. Industrial emissions include smoke, odors, dusts (metallic and inorganic), and lint.

The Dyersburg area used 626,088,000 cubic feet of gas in 1956. Coal usage was estimated at 4000 tons. Little other fuel was used. In addition, the municipal electric power plant used 14,000 tons of coal and 689,149,000 cubic feet of gas. This plant will discontinue operation in July of 1957, when the city will begin to purchase its electric power from TVA.

Refuse is disposed of on an open dump which emits smoke and odor. However, no complaints have been received concerning its operation and apparently it is not a major problem.

Motor vehicle registration for Dyer County was 12,085 in 1956. Estimated annual gasoline consumption was 10 million gallons. Dyersburg is served by two railroads (almost exclusively diesel-powered) and one Federal highway.

An extrajurisdictional pollution problem involving lint from citton gins located in an adjoining county reportedly creates a problem in Dyer County.

There are some operations in and around Dyersburg that emit objectionable amounts of atmospheric pollutants and cause limited discomfort or inconvenience to residents. Complaints have been received concerning air pollution, principally from industrial sources, particularly the cotton gins. Pollution problems include lint from the gins and cotton oil plants, smoke from the city power plant and several commercial stacks, and a "fishy odor" from the Mississippi lowlands. The cotton gin problem is seasonal and limited to the area immediately surrounding the gin. These gins also produce smoke from burning hulls. In general, air pollution problems are believed to be minor.

There is a local smoke ordinance, with the fire department responsible for enforcement. There is very little or no enforcement of the ordinance, although the fire chief has made some smoke density determinations and has investigated complaints.

Crockett County, a part of the Dyer-Crockett District Health Department, reportedly has little or no air pollution problem.

## Rest of Region I

There are 17 other counties in this region. These counties are covered by 13 local health departments. They are similar in topography and climate to the areas previously discussed in this region. These counties have a total population (1955) of 375,500 and range from 9065 (Decatur) to 47,400 (Gibson).

In this area generally, a decrease in population has occurred from 1940-1955. Population projections indicate that a slight (3 percent) increase in population is expected from 1955 to 1965.

This area is primarily rural and its economic life is based on agriculture. Total manufacturing employment (1956) was 18,600, of which 6418 were in Gibson County.

Of the 13 local health departments, 10 reported objectionable amounts of pollutants, 10 reported discomfort or inconvenience to residents, 4 damage to property, and 1 injury to animal life; 11 indicated they received complaints on pollution, 4 indicated air pollution problems were due to dumps, 1 to commercial activities, and 10 to industry; 6 local health departments considered their pollution problem to be of major significance. Four indicated some local activity to control air pollution, and one reported air pollution to be extrajurisdictional in nature.

The most common air pollution problem in this area is lint (and smoke) from the cotton gins. This problem is seasonal in that gins are operated only in the fall and the problem affects only a local area around the plant. Ginning operations are geographically widespread and the lint problem has caused many complaints. Another common problem involves smoke and odor from burning refuse dumps. The clay industry contributes to the pollution picture. Problems have been indicated due to dust from clay processing, hammer mills, and processing fuller's earth. Additional problems include odors from slaughter houses and cocking garbage for hogs, odors from tanneries and a shoe manufacturer, dust from seed corn cleaning, acid and lead fumes from a battery plant, high silica dust from sand companies and monumental works, odor from sewage in creeks, smoke and odor from shale burning, and coal smoke from commercial establishments. Generally no pollution problems have been reported due to residential sources. Vehicular traffic is not heavy, and there is not much coal used for residential heating.

## AIR POLLUTION IN REGION II

Topographically, this region is a highly dissected plateau ranging in elevation from 700 to over 1000 feet above sea level. Climatic conditions appear generally favorable for dispersion of pollutants, but since it is a region of hills and valleys, the local weather conditions will be greatly varied. During certain atmospheric conditions pollution may accumulate in the valleys.

The 11 counties in this area have a total population of 163,500 (est. 1955) and a manufacturing labor force of 8400 (1956). Population projections to 1965 predict a growth in population to 174,865. The larger industries are food, leather, apparel, and lumber. Montgomery County alone accounts for 28 percent of the population and 33 percent of the manufacturing labor force.

The area is primarily rural. Clarksville is the only city of over 10,000 population.

### Clarksville

The county seat of Montgomery County, Clarksville is situated in a valley formed by the Cumberland and the Red Rivers. The city is surrounded by hilly terrain, but the hills generally do not rise appreciably above the elevation of the city. No climatological data were found available. However, because of its valley location, there would be times when stable atmospheric conditions would inhibit dispersion of pollutants. The 1955 population of Clarksville was 16,865. Population estimates indicate a growth of 20 percent for the city from 1955 to 1965, and 40 percent for the entire county to the year 2000, over the 1955 county population of 45,000.

Industrial employment for Clarksville (1956) is about 2735. The larger industries are food, rubber, and leather. There is also a foundry and there are several crushed limestone plants. Industrial emissions noted were odor, dusts (feed and limestone), tobacco, and foundry dust.

Part of the large population is accounted for by the presence of a nearby military base (Camp Campbell).

Fuels used for heating are mainly gas, oil, and electricity. There is also some coal burned for industrial and commercial purposes, although it was noted that there is not much of an air pollution problem from fuel consumption.

Refuse was disposed of on a dump located within the city limits. Refuse formerly was burned, creating a local smoke and odor problem; but the city has since (late 1956) changed to an improved land fill operation, thus eliminating this source of pollutants. There were 15,692 motor vehicles registered in the county in 1956. These vehicles consumed an estimated 13 million gallons of gasoline. No pollution from natural sources or from an extrajurisdictional area was reported.

None of the operations in Clarksville were reported to emit objectionable amounts of pollutants, excluding the dump (which has now been remedied), and complaints concerning pollution have not been received. Although some smoke and odor problems were noticed at the time of the survey, these were judged to be of minor import. Without information to the contrary, air pollution problems in this area are judged to be of minor importance.

There is neither a local control ordinance nor a program in the air pollution field.

### Rest of Region II

There are 10 other counties covered by 6 local health departments in Region II. These counties have a total population (1955) of 118,600 and range from 4965 (Houston) to 28,485 (Lawrence). For this area generally, a decrease in population has occurred from 1940 through 1955. Population projections indicate that a slight increase in population (3 percent) is to be expected from 1955 to 1965.

This area is primarily rural. Total manufacturing employment (1956) was 5665, with 40 percent accounted for by Dickson and Lawrence Counties. Industrial emissions noted were foundry dusts, mists from electroplating operations, fluoride and dust from grinding and acidulation of rock phosphate, fumes from the iron industry, and odors and tars from the manufacture of charcoal.

Of the six local health departments in this area, two reported objectionable amounts of pollutants with resultant discomfort or inconvenience to residents, one noted complaints received, two attributed their problems to the municipal dump and one to industrial problems. In only one was the problem considered of major significance, but this county indicated corrective measures were being taken. One indicated some control regulations, and one indicated some local activity in the air pollution field.

It is concluded that there are only localized air pollution problems in this area and that they are not considered of major significance. Several industrial operations emit objectionable amounts of material, but are so located as to cause no considerable problem at this time.

## AIR POLLUTION IN REGION III

Topographically, this region consists of the central basin and adjoining counties to the north and south. The basin is entirely surrounded by a rim 400 or more feet high. The general surface of the basin is gently rolling with outliers from the rim and residual knobs rising 200 to 300 feet above the general level. Climatic conditions are not as favorable to the dispersion of pollutants as in western Tennessee but generally are conducive to an adequate dispersion. There are periods, however, particularly in the fall, when pollutants tend to accumulate. (See particularly Nashville in this section.)

The 19 counties in this region have a total population of 707,600 (est. 1955). Population projections to 1965 predict a substantial growth to 792,200. The estimated manufacturing labor force (1956) is 56,515, with 64 percent located in Nashville (Davidson County). Major industries are textiles, leather, tobacco, apparel, food and fabricated metals in the more rural counties, and these, plus chemicals, printing, electrical equipment and primary metals in the more urban counties.

Primary fuels used in this area are coal and gas, also some oil and electricity. As is characteristic of the State generally, the use of coal is decreasing with a corresponding increase in gas and, for newly constructed homes, electricity.

Nashville, Murfreesboro, Columbia, and Shelbyville are the cities in this region with over 10,000 population.

### Nashville

The county seat of Davidson County, Nashville is situated in the northwest corner of the central basin near the eastern escarpment of the highland rim. This rim, situated about seven miles from downtown Nashville, forms an amphitheater about the city on the south, west and north, with hills approximately 300 to 400 feet high. The country to the northeast, east, and southeast is more or less open, but undulating, with hills of about 100 feet elevation. The Cumberland River flows through Nashville generally in an east to west direction. It has cut a narrow channel through the rim to the west. Selected climatological data are given in Table 26.

During most of the year, atmospheric conditions are generally favorable to the dispersion of pollution. However, there are occasions during the fall and early winter when the atmosphere is unable to sufficiently disperse the airborne materials, and pollutants often tend to collect over the city. It is at this time also that heating with soft coal adds an additional burden of pollution to the atmosphere. Thus, there are frequent evenings and mornings when a pall of smoke and other pollutants hang over the city.

Population estimates for Nashville and Davidson County indicate a substantial growth (Table 27). The greatest part of this growth is expected to be in the suburban area around the city.

Industrially, Nashville places fourth among the four metropolitan areas of Tennessee. Of a total nonagricultural employment of about 135,000 (1957), almost 38,000 were employed in manufacturing. The leading industries are printing, chemicals, food products, fabricated metals and leather, with others being textiles, apparel, stone, clay and glass, and furniture. Detailed employment data are given in Appendix C. Industrial emissions include smoke from coal combustion and auto scrapping establishments; dust from crushed limestone, cement, and brick works; acid, dust, ammonia, and fluorides from fertilizer and phosphate plants; foundry and cupola emissions; acids and lead from battery plants; acids and alkalies from electroplating; dust and phosphorous oxides; carbon disulfide and hydrogen sulfide from a rayon plant; and emissions of hydrocarbons, lint, zinc, acetylene, paint spray, aldehydes, solvents, nicotine; and odors from various sources.

TABLE 27

POPULATION OF NASHVILLE AND DAVIDSON COUNTY[1,3,5]

| YEAR | DAVIDSON COUNTY | NASHVILLE | REST OF COUNTY |
|---|---|---|---|
| 1940 | 257,267 | 167,402 | 89,865 |
| 1950 | 321,758 | 174,307 | 147,451 |
| 1955 | 345,377 | 175,521 | 169,856 |
| 1960 | 378,695 | 183,023 | 195,672 |
| 1965 | 410,395 | 189,356 | 221,039 |
| 2000 | 550,000 | - | - |

The major fuel used in the Nashville area is coal, although considerable gas is used and electric heat is popular in new dwelling units outside the city proper. Coal usage in 1955 amounted to 428,244 tons. This is all bituminous

TABLE 26

SELECTED CLIMATOLOGICAL DATA FOR NASHVILLE[40,16]

1949-1954

| MONTH | DEGREE DAYS | PRECIPITATION | MEAN HOURLY WIND SPEED (M.P.H.) | PREVAILING WIND DIRECTION | PERCENT CALMS | PERCENT POSSIBLE SUNSHINE | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|---|---|
| JANUARY | 778 | 4.9 | 9.6 | S | 14 | 42 | 1 |
| FEBRUARY | 656 | 4.3 | 9.8 | S | 20 | 47 | 1 |
| MARCH | 498 | 5.3 | 10.4 | S | 16 | 54 | 1 |
| APRIL | 186 | 3.7 | 10.1 | S | 18 | 60 | - |
| MAY | 43 | 3.8 | 8.4 | S | 33 | 65 | - |
| JUNE | 0 | 3.2 | 7.6 | S | 30 | 69 | - |
| JULY | 0 | 4.0 | 7.0 | S | 38 | 69 | 1 |
| AUGUST | 0 | 3.3 | 6.7 | S | 41 | 68 | 1 |
| SEPTEMBER | 22 | 2.7 | 7.2 | N | 39 | 69 | 1 |
| OCTOBER | 154 | 2.5 | 7.6 | S | 43 | 65 | 2 |
| NOVEMBER | 471 | 3.4 | 9.0 | S | 23 | 55 | 1 |
| DECEMBER | 725 | 4.1 | 9.2 | S | 21 | 42 | 2 |
| YEAR | 3,513 | 45.2 | 8.6 | S | 28 | 59 | 11 |

and is mainly used in industry, although as recently as 1950, 65 percent of the residential dwellings were heated by coal.[15] The use of coal has been declining; in 1946, for instance, 942,978 tons of soft coal were used in Nashville, but the combustion of fuel, particularly soft coal, is presently an important source of pollution in Nashville. Natural gas consumption in Davidson County and Nashville amounted to 111,388,425 therms in 1956 (approximately 10.3 billion cubic feet), of which 36,300,000 therms were used by residential customers. This does not include large industrial users who buy direct from the main lines. It has been estimated that approximately one-third of the homes in the county (including Nashville) are heated by gas and about one-third are heated electrically. No general figure on oil consumption is available, but consumption runs well over a million gallons annually.

Refuse from Nashville and Davidson County is disposed of in land fills, eliminating pollution from the refuse disposal operation. Apparently the practice of "back yard burning" of rubbish is widespread in the city and causes local complaints as well as adding to the over-all pollution load.

The 132,443 motor vehicles registered in Davidson County in 1956 consumed an estimated 110,000,000 gallons of gasoline. The 24-hour annual average traffic flow into and out of the city is 184,420. Fumes from vehicles are a source of public complaint. In addition to automotive exhaust, there are exhausts from city buses and 3 railroad lines operating 51 trains per day (all diesel). In addition, the city is served by 7 bus lines, 47 motor freight lines, 10 Federal highways, and several barge lines.

No specific sources of pollution outside Davidson County which affected residents in the county were reported. There is quite an extensive industrial development in the county adjacent to the Nashville city limits which is the cause of air pollution complaints from city residents.

There are certain specific operations in the Nashville area which emit objectionable amounts of pollutants to the air in sufficient quantities to cause discomfort or inconvenience to residents and, in instances damage to property. Complaints concerning air pollution have been received. These have included fumes from vehicular traffic, odor from plants where oil is reclaimed, odor and smoke from automobile scrapping, odors from restaurants, dust from fertilizer plants and crushed limestone plants, lead fumes and acid mists from battery plants, dust from a cement plant, foundry emissions, and smoke from the State-owned power plant. Also, the widespread use of soft coal for residences, commercial establishments and industry has been previously noted as a major problem. In general, air pollution is attributed to domestic, commercial and industrial sources and is considered of major significance.

There is a local smoke ordinance and a smoke inspector who carries on a program of control. This program is not adequate to cope with the problem. The city recently (January 1957) joined the U.S. Public Health Service's National Air Sampling Network.

Results of eight months of sampling showed that Nashville had an average particulate loading of 132 micrograms per cubic meter of air; individual values ranged from a low of 77 to a high of 255. Values of particulate loading for Nashville are quite close to those of other cities of comparable size participating in the National Air Sampling Network. The average concentration of organic material (benzene soluble material) was 9.8 micrograms per cubic meter of air; individual values ranged from a low of 3.5 to a high of 19.8.

Nashville has had a long history of major smoke problems. In a report dated 1932, it was said[42] ". . .certain observations (were) made during several winters (four winters) beginning in 1927-28. The observations in question were made from the Weather Bureau Office in the Stahlman Building, and concerned the density of smoke as observed from that point. . . Density was graded on the Ringelmann Scale. . . The following table gives the monthly averages for the four winters at the hours specified:

| Month | 7 A.M. | 9 A.M. | 12 Noon | 4 P.M. |
|---|---|---|---|---|
| December | 2.3 | 2.1 | 1.5 | 1.4 |
| January | 2.1 | 1.9 | 1.5 | 1.2 |
| February | 2.1 | 1.8 | 1.2 | 1.1 |
| Winter | 2.2 | 1.9 | 1.4 | 1.2 |

"The detailed records show that there was some smoke nearly every day in the winter months. Although there were several periods of three or four consecutive days when none was observed." In 1935, it was reported[43], "Few cities in the United States have a greater smoke nuisance to contend with during the winter months than Nashville, Tennessee. It has been so dense on occasions that the visibility was reduced to zero, the sun's disc invisible from street level, and street and automobile lights kept burning until after 10 A.M., although at the same time just outside the smoke area the sky was brilliantly clear." And as recently as 1946 it was reported[44], "The Nashville smoke height is approximately 250 feet with a radius of approximately four miles. Formation of smoke shroud over the city is directly due to meteorological conditions combined with local geographical features which go to make up a perfect union for stagnation of the lower atmosphere."

While the smoke problem is not as severe now as it was 10 or 20 years ago, considerable further improvement could be made. The problem in Nashville is not amenable to a simple solution. It is particularly bad during the fall of the year when adverse atmospheric conditions, the onset of the residential heating season, and other pollution emissions combine to produce a smoke pall over the city. Industrial emissions of many types throughout the area, including smoke, fumes from vehicular traffic and emissions from industrial concerns contribute to the problem.

### Murfreesboro

The county seat of Rutherford County, Murfreesboro is situated in the geographic center of the central basin. The countryside is fairly open around the city, with a few knobs rising 100 to 300 feet located four to five miles away in the northwest, west, southwest and south directions. While no climatological data were found available, it may be said (from other data) that climatic conditions are generally favorable for dispersing pollutants. Being in the central basin, however, it may be assumed that, on occasions, during the fall and early winter, conditions may be unfavorable for dispersing pollutants, as in Nashville

Population of Murfreesboro was 14,736 in 1955. Population estimates for the city predict a substantial growth of 24 percent from 1955 to 1965 and 7 percent for the rest of the county during the same years.

Rutherford County is primarily a dairy section. The county has a manufacturing employment of 1340 (est. 1956). Major industries are food (particularly dairies) and textiles.

Refuse is disposed of in a land fill and there is little back yard burning of rubbish. The 16,701 motor vehicles registered in the county consumed an estimated 13,900,000 gallons of gasoline. The railroads are all diesel-powered. No instance of extrajurisdictional pollution problems was reported.

There are operations that occasionally emit objectionable amounts of pollution to the atmosphere in sufficient concentration to cause discomfort or inconvenience to residents and damage to vegetation. Complaints have been received concerning air pollution, generally attributed to industrial sources. Problems noted include coal smoke from residences, industry and government buildings; odor from a whey processing plant; and dust and fluoride from a fertilizer plant located in the county. Problems are of an occasional nature and are considered of minor importance.

### Columbia

The county seat of Maury County, Columbia, with a 1955 population of 11,070, is situated in the central basin in a fairly open area. The highland rim, rising 250 to 350 feet, is situated about 10 miles west of the city. There are also hilly areas nearby. No weather data are available; but from the openness of the terrain, it would appear that climatic conditions are generally favorable to the dispersion of pollutants.

Population projections indicate a moderate growth for the area. The city is expected to gain 10 percent between 1955 and 1965, while the county as a whole is expected to gain 7 percent.

Manufacturing employment in the county is 4120 (est. 1956). The largest industry in this area is chemicals (related to the phosphate industry). Other large industries are electrical equipment and apparel. Industrial emissions include fluoride and dust from the phosphate industry, graphite (carbon) particles, hydrogen sulfide and carbon disulfide, feed dusts, and odors from the food industries.

Actual fuel consumption is not known, but residential heating in 1950 was 65 percent, coal; 13 percent, oil; 6 percent gas; 3 percent, electric; and others, 13 percent. Coal smoke, associated with residential heating, is a problem of limited extent. Refuse is disposed of on a land fill, and back yard incineration of refuse is limited.

Maury County had 15,629 motor vehicles registered in 1956. The estimated annual gasoline consumption of these vehicles was 13 million gallons. The railroads in this area are all dieselized. No problem is noted in connection with transportation. Instances of extrajurisdictional sources of air pollutants were not noted.

There are operations in Maury County which emit objectionable amounts of pollutants and cause discomfort or inconvenience to residents, damage to vegetation, and injury to animal life. Complaints concerning air pollution have been received concerning fluoride emissions from fertilizer and phosphorus plants, carbon particles from a graphite plant, hydrogen sulfide odor from a cellulose sponge plant, and odors from renderers. The major problem here is the fluoride emissions which have been reported to cause an adverse effect on cattle. Air pollution problems are considered of major significance. There are no local ordinances for control of pollution, but the Health Department has done some work in the air pollution field.

### Shelbyville

The county seat of Bedford County, Shelbyville, with a 1950 population of 9455, is in a fairly open area of the central basin. Two or three miles to the south and southeast, hills rise to some 250 to 400 feet. Climatological conditions for the dispersion of pollutants are likely to be satisfactory.

Population projections for the county indicate a moderate growth of 7 percent from 1955 to 1965. Manufacturing employment for Bedford County is 2460. The larger industries are lead pencil companies, apparel, and textiles. Industrial emissions in Shelbyville include smoke and sawdust from pencil companies, dust from feed mills and limestone plants, odors from food companies, lint, and graphite. Fuel consumption data are unknown, but reportedly there is little coal smoke. Refuse is disposed of in a land fill. Motor vehicle registration for Bedford County was 9303 in 1956. Gasoline consumption is estimated at 7,700,000 gallons. The railroad engines are mostly diesel-powered. No cases of extrajurisdictional air pollution problems were noted.

There are operations in Shelbyville which occasionally emit objectionable amounts of pollutants, causing discomfort or inconvenience to residents and property damage. Complaints concerning air pollution attributed to industrial sources, as stated above, are local area problems and are considered of minor significance.

There are no local ordinances for smoke control, but the Health Department has undertaken some work in the air pollution field in complaint investigations.

Marshall County, a part of this district health department, had a 1955 population of 18,100, with a growth of 5 percent expected by 1965. Manufacturing employment is 2280. The larger industries are lead pencil companies, leather, food and primary metals. In Marshall County industrial emissions include smoke and sawdust from pencil companies, odors from food companies, and acids and other material from electroplating. Refuse is disposed of on an open dump.

### Rest of Region III

There are 14 other counties in Region III covered by eight local health departments. These counties have a total population (1955) of 237,425, ranging from 3850 (Moore) to 38,025 (Sumner). The population in 1950 was 242,835; predicted population for 1965 is 243,700. The manufacturing employees numbered 10,335 in 1956.

This area is predominantly rural, with an agriculture-based economy. Some 9 out of 10 acreas are farms with pasture land exceeding crop land by about one-third. It is the leading live stock area of the State, especially noted for dairy cattle, sheep, and chickens. Some rock phosphate is mined in Giles and Williamson Counties. There is not a large manufacturing industry. The leading industries are apparel and textiles, and some leather, fabricated metals, tobacco, and food concerns. Industrial emissions noted included smoke and odor from junking automobiles, dust from rock crushing, dust and fluorides from the phosphate industry, and odors from food concerns.

Of the eight local health departments, two reported objectionable amounts of pollutants, two reported discomfort or inconvenience to residents, one indicated they received complaints on pollution, one indicated pollution problems were due to dumps, one to commercial activities, and two to industry. No problems were considered of major significance. One indicated some local activity in the air pollution control field and two reported air pollution to be extrajurisdictional in nature. Both of these extrajurisdictional problems involved the same source, the rayon plant in Davidson County, which emits hydrogen sulfide and carbon disulfide.

From the foregoing information, it appears that air pollution problems are restricted to local nuisance problems, are of minor significance, and, with little or no population and industrial growth anticipated, the problem will not become appreciably worse.

## AIR POLLUTION IN REGION IV

This region consists of two physiographic divisions: the eastern highland rim and the Cumberland plateau. The highland rim is a gentle plain, averaging 1000 feet in elevation, while the plateau is a flat, rolling tableland with a general elevation of 2000 feet. Limited available climatological data indicate an annual southerly prevailing wind, a low occurrence of calms (4 percent), and an average annual rainfall of 55 inches. General climatic conditions appear favorable for dispersing pollutants. However, in the region of hills and valleys, there would be occasions during light winds and stable atmospheric conditions when the valleys would restrict dispersion of pollutants.

There are no cities in this region with 10,000 population or more. Only three cities have over 5,000 population. There are 14 counties covered by nine local health departments. These counties had a population (1955) of 228,400, ranging from 3930 (Van Buren) to 30,660

(Putnam). A population of 241,925 is anticipated in 1965, a six percent increase over 1955.

Manufacturing employment was 14,150 (est. 1956). The larger industries are apparel and lumber, with others being leather, textile, fabricated metals and miscellaneous. Noted industrial emissions include dust from rock crushing, cement plants and machinery operations, and emissions from cupolas. Minerals produced in this Region include coal, stone, and cement. While no data were obtained on fuel usage, it is known that coal is the predominant fuel for urban areas. In Cookeville, for instance, according to the 1950 Census of Housing, coal was used to heat 67 percent of the houses, oil 17 percent, electricity 6 percent, wood 5 percent, gas 4 percent, and other 1 percent. In the rural areas coal and wood predominate.

This region is predominantly rural. Only about a quarter of the population resides in incorporated areas. Agriculture is of the small general farm variety. Only around Franklin County is there any commercial type of agriculture. Generally, the area is rather thickly wooded.

Of the nine local health departments, four reported objectionable amounts of pollutants, three reported discomfort or inconvenience to residents, four indicated air pollution problems were due to dumps, and one to industrial activity. None considered their pollution problem to be of major significance. One reported some local activity to control air pollution.

Thus, the major pollution sources are municipal dumps. There are a few industrial sources which have created local nuisance problems. Existing problems are apparently of minor significance. The small anticipated population growth would indicate little chance of an appreciable worsening of the air pollution situation in this area.

## AIR POLLUTION IN REGION V

Topographically, this region consists of the Great Smokies, the great valley of east Tennessee, and part of the Cumberland plateau. It is a region of mountains and valleys. On the east, the Smokies rise to a general elevation of 4500 feet. On the west is the Cumberland plateau which has a general elevation of 2000 feet in the southern portions and a mountainous terrain of about 3500 feet in its northern portions. In between the Smokies and the plateau lies the great valley, a series of parallel valleys and ridges. The valleys slope down from a 1500-foot elevation in the north to a 600-foot elevation in the south; the ridges from 2500 feet in the north to 1200 feet in the south. The cities, industry, and population all lie in the great valley section. This is the region where periods of prolonged air stagnation could most likely lead to air pollution situations of great concern. This is particularly the case in the fall and early winter.

The 30 counties in this region have a population of 1,303,885 (est. 1955), of which 43 percent live in Knox, Hamilton and Sullivan Counties. The estimated 1965 population is 1,510,637 (a 16 percent growth), of which the three counties will account for 45 percent. This region promises the greatest population and industrial growth in the State.

There are 126,340 manufacturing employees in this region, of whom 60 percent are located in Knox, Hamilton and Sullivan counties. There is a great diversity of manufacturing industries. Some of the leading ones are textiles, chemicals, apparel, primary metals, furniture, food, fabricated metals, stone, clay and glass, paper, printing, and lumber. Industry contributes both a wide variety and a considerable amount of material to the atmosphere. Generally, industry is located in the larger cities. The 10 counties having a city with over 10,000 population have 85 percent of the industry.

The primary fuel consumed in this area is soft coal. It is only in recent years that natural gas has become generally available. Liquid fuel and electricity are also used for residential heating. Thus, smoke from the consumption of soft coal has been a general problem of this area.

There are 11 cities in this area with over 10,000 population.

### Chattanooga

The city of Chattanooga, county seat of Hamilton County, is located in a valley four to five miles wide, with Missionary Ridge on the east and a series of ridges and hills on the west. The latter are in line with Lookout Mountain, either side of which is a valley extending to the south. These ridges (except for Lookout Mountain) rise from 100 to 250 feet above the city. Beyond Missionary Ridge to the east there are no topographical obstructions for many miles; to the west of Lookout Mountain, at a distance of about four miles, are Signal Mountain and other members of the eastern portion of the Cumberland plateau. Lookout Mountain and the plateau are about 1300 feet above the city. Thus, the city is confined east and west by a series of ridges, and further to the west and in the southwest by mountains of considerable altitude. The Tennessee River winds through the valley. Selected climatological data are given in Table 28.

These data (Table 28) show Chattanooga to have a relatively mild heating season, an abundant amount of precipitation, a low mean monthly wind speed (particularly in the summer and early fall), a relatively high occurrence of heavy fog, and prevailing wind directions of south-southeast and north-northwest paralled to the valley axis. The city is subject to frequent low level temperature inversions, particularly in the fall and early winter months. During such periods air-borne pollutants are fairly well confined to the valley. During other periods of the year when atmospheric conditions are less stable, the dispersion and transport of pollutants are likely to be more favorable. This combination of topographic-climatological characteristics makes the city of special interest from the point of view of air pollution control.

Population estimates for Chattanooga and Hamilton County indicate a fairly static population in the city but a substantial growth for the county (Table 29).

Of the total nonagricultural employment of 91,000 (est. 1957), 43,400 were employed in manufacturing. The leading

TABLE 28

SELECTED CLIMATOLOGICAL DATA FOR CHATTANOOGA[18,40]

1949-1954

| MONTH | DEGREE DAYS | PRECIPITATION | MEAN HOURLY WIND SPEED (M.P.H.) | PREVAILING WIND DIRECTION (a) | PERCENT CALMS | PERCENT POSSIBLE SUNSHINE | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|---|---|
| JANUARY | 725 | 5.2 | 7.6 | SW | 32 | 43 | 3 |
| FEBRUARY | 607 | 5.3 | 8.2 | W | 33 | 45 | 2 |
| MARCH | 467 | 6.0 | 8.5 | W | 28 | 50 | 1 |
| APRIL | 179 | 4.5 | 8.1 | SE | 32 | 58 | 1 |
| MAY | 45 | 4.2 | 6.4 | NW | 47 | 62 | 1 |
| JUNE | 0 | 4.2 | 5.8 | NW | 52 | 65 | 1 |
| JULY | 0 | 5.3 | 5.5 | NW | 55 | 61 | 1 |
| AUGUST | 0 | 3.7 | 5.1 | W | 61 | 61 | 2 |
| SEPTEMBER | 24 | 2.7 | 5.1 | W | 59 | 65 | 2 |
| OCTOBER | 169 | 3.2 | 5.6 | NW | 58 | 64 | 5 |
| NOVEMBER | 477 | 4.0 | 6.7 | SW | 46 | 53 | 4 |
| DECEMBER | 710 | 5.3 | 7.1 | SW | 41 | 41 | 4 |
| YEAR | 3,384 | 53.8 | 6.6 | W | 45 | 56 | 27 |

(a) At the airport located east of Missionary Ridge.

TABLE 29

POPULATION FIGURES FOR CHATTANOOGA[1,3,5]

| YEAR | HAMILTON COUNTY | CHATTANOOGA | REST OF COUNTY |
|---|---|---|---|
| 1940 | 180,478 | 128,163 | 52,315 |
| 1950 | 208,255 | 131,041 | 77,214 |
| 1955 | 218,392 | 128,851 | 89,541 |
| 1960 | 234,945 | 131,640 | 103,305 |
| 1965 | 250,645 | 133,744 | 116,901 |
| 2000 | 315,000 | • | • |

industries are textiles, fabricated metals, chemicals, primary metals, stone, clay and glass, and food. Noted industrial emissions include smoke from wire salvaging, smoke and odor from burning junked cars and tires, foundry, especially cupola, emissions, odor from a rendering plant, dust from a cement plant, smoke from brick works, dust from a glass company, odor from a food company, paint spray, smoke from burning wood wastes, zinc and ammonium chloride from galvanizing operations, emissions from heat treating and annealing, acids and alkalies from electroplating, fumes from a brass foundry, fluorides from an aluminum foundry and acidulation of rock phosphate, acid mist from a battery plant, titanium tetrachloride, tars, chlorine from unspecified sources, ferrosilica, chrome, manganese and tars from an electrometallurgical plant, odors and tars from road material producer, creosote odor, oxides of nitrogen, solvents and varnish from a paint company, solvents from enameling operations, odors from a tannery, dust and odors from chemical companies, dust from ceramic companies, odor from burning varnish and insulation, and smoke from burning coal and wood wastes for fuel. There is a great diversity of industry and the contribution to the general pollution load is significant. Of particular note are the emissions from the many foundries where cupolas generally have no controls, from electrometallurgical operations and other primary metal plants, and from the stone, clay and glass works.

The major fuel used in this area is coal, although gas and oil are used and electric heat is popular in new dwelling units. All coal used is bituminous, of medium and high volatility, mainly used in industry, although as recently as 1950, 67 percent of residential heating was with coal. Coal usage, excluding large companies which buy direct from local mines, is estimated at 285,000 tons. As is characteristic of the State generally, the use of coal has been declining somewhat in recent years. Natural gas consumption for 1956 amounted to almost 9.5 billion cubic feet, of which one billion was used by residential customers, one billion by commercial customers, and 7.5 billion by industry. Fuel oil usage for heating purposes is estimated at 300,000 gallons. It was also estimated that 36 percent of residential electric users heated electrically. The consumption of fuels, particularly coal, is a significant source of pollution in Chattanooga. Decreasing coal usage, the conversion of railroads to diesel, and the local air pollution program have substantially reduced the coal smoke problem over the years.

Refuse is disposed of in land fills, although the city also operates one dump within the city limits. Burning on this dump creates a smoke and odor problem which has been noted as a major nuisance problem and source of general pollution. There is little back yard burning of rubbish.

The 80,553 motor vehicles registered in Hamilton County in 1956 consumed an estimated 67 million gallons of gasoline. The 24-hour annual average traffic flow for Chattanooga is 110,000. It has been reported that vehicular exhausts make a significant contribution to the over-all pollution load and pose a greater future problem. In addition to automotive exhausts, there are also exhausts from city buses and four railroads (all diesel). The city is served by 5 Federal highways, 33 common carrier truck lines, 11 bus lines, and 7 barge companies.

Chattanooga is involved in several interjurisdictional pollution problems. There is quite a concentration of industries just outside the city limits in

Hamilton County which affect residents in the city. On the other hand, certain industrial emissions within the city have caused complaints from residents outside the city. There is also an interstate pollution problem involving Chattanooga and Rossville, Georgia.

There are operations in the Chattanooga area which emit objectionable amounts of pollutants to the air in sufficient quantities to cause discomfort or inconvenience to residents and damage to property. Complaints concerning air pollution have been received. These complaints have concerned burning on the city dump, burning of junk autos, emissions from many foundries, odor from a rendering plant and a tannery, dust from a cement plant, emissions from an electrometallurgical plant and smoke from burning wood wastes, from private residences, from government buildings, and from commercial buildings. Air pollution is attributed to municipal, domestic, commercial, and industrial sources and is considered of major significance.

In a paper[45] prepared in 1954 it was said, "Chattanooga is an industrial city, so located as to topography and climatology as to intensify the effects of air pollution resulting from the use of fuels of high volatile content and from fumes incidental to certain manufacturing operations."

There is a local air pollution ordinance for Chattanooga and, at present a two-man staff carries on a program of control. While over the years this program has made considerable progress, it is inadequate for the size of the problem. The city is participating in the National Air Sampling Network of the Public Health Service. Results of two years of sampling show that Chattanooga had an average particulate loading of 142 micrograms per cubic meter of air for a "residential and suburban" area and 238 micrograms per cubic meter for a "commercial" area. This value is considerably in excess of the median of other cities of comparable size participating in the National Air Sampling Network. Other data are given below:

| | | R & S[a] | C[b] |
|---|---|---|---|
| Particulate Loading | Aug<br>Max<br>Min | 142<br>350<br>30 | 238<br>644<br>91 |
| Organic Matter (Benzene-Soluble) | Aug<br>Max<br>Min | 9.8<br>46.7<br>0.9 | 21.2<br>73.3<br>6.9 |

(a) Residential and Suburban area.
(b) Commercial area.

The city has also made determinations on its own of air pollution by means of dustfall jars, high-volume samplers, and electrostatic precipitators. Some results of this sampling program are given in Table 30. Dustfall data have been collected since 1935. The commercial area has shown a decline in dustfall, as has the railroad area (reflecting, first, the use of overfire steam jets and, second, conversion to diesel). Industrial area fall-out increased during the war but has since declined. The residential area follows the industrial trend.

## Cleveland

The county seat of Bradley County, Cleveland, with a 1955 population of 13,050, is situated in a fairly narrow, shallow valley. The valley is about 2 miles wide and the sides rise 100 to 200 feet above the city. Five miles to the northwest a ridge rises 500 feet above city elevation, and 10 miles to the southeast mountains rise 1100 feet. The valley is oriented northeast-southwast. No climatological data were found available. However, the expected climatic features of Cleveland would be similar to those of Chattanooga.

Population statistics for Cleveland indicate a fair growth of 13 percent for

TABLE 30

AIR POLLUTION DATA FOR CHATTANOOGA

| DUSTFALL,- TONS/SQUARE MILES/MONTH | | | | | |
|---|---|---|---|---|---|
| | YEAR | COMMERCIAL | INDUSTRIAL | RESIDENTIAL | RAILROAD |
| HEATING SEASON | 1940 | 65 | 50 | 17 | 73 |
| | 1944 | 45 | 65 | 17 | 77 |
| | 1948 | 31 | 75 | 27 | 51 |
| | 1952 | 24 | 28 | 22 | 42 |
| | 1954 | 28 | 34 | 19 | 18 |
| NON-HEATING SEASON | 1944 | 33 | 52 | 11 | 62 |
| | 1948 | 25 | 59 | 16 | 33 |
| | 1952 | 20 | 31 | 17 | 27 |
| | 1954 | 21 | 27 | 12 | 25 |

| AIRBORNE PARTICULATE MATTER, - 1953 - MG./CUBIC METER | | |
|---|---|---|
| ZONE | AVERAGE | RANGE |
| RESIDENTIAL | 0.35 | 0.03 - 1.62 |
| COMMERCIAL | 0.52 | 0.06 - 1.67 |
| INDUSTRIAL | 1.21 | 0.06 - 14.20 |
| HEAVY INDUSTRIAL | 1.58 | 0.06 - 14.20 |

1965 over 1955. For all of Bradley County, an increase of 27 percent is expected from 1955 to 2000.

Primary fuel used in Cleveland is coal, although natural gas and oil are available and used. There are 4320 manufacturing employees in Bradley County (est. 1956), and the leading industries are textiles, apparel, furniture and fabricated metals. Industrial emissions include smoke, odors, and emissions from foundry and enameling operations. There were 13,607 motor vehicles registered in the county in 1956, which consumed an estimated 11 million gallons of gasoline. The annual average daily traffic flow for Cleveland is about 25,000. The railroads serving the city are dieselized. Refuse is disposed of on a land fill. Poor operation results in a smoke and odor problem.

One major source of extrajurisdictional pollution was noted. A paper plant located about 13 miles up valley causes a strong unpleasant odor in the city. There are operations in the Cleveland area which emit objectionable amounts of pollution to the atmosphere in sufficient concentrations to cause discomfort or inconvenience to residents. Complaints have been received concerning air pollution. Problems noted were odors from a dump, coal smoke, odor from the paper mill, smoke from foundries and odor from an enameling plant. In general, air pollution problems are attributed to municipal and industrial activities and are considered of minor importance.

## Southeastern Section of Region V

Five other counties (McMinn, Meigs, Monroe, Polk, Rhea) comprise this southeast corner of the State. These counties have a total population (1955) of 92,400, ranging from 5890 (Meigs) to 32,220 (McMinn). The 1950 population of this region was 94,732; the 1965 projection is 99,250.

Athens is the one city of over 10,000 population in this area. The county seat of McMinn County, Athens is located in a shallow valley or bowl between higher parallel ridges. The 1956 population is estimated as 11,000. Leading industries are textile, furniture, and paper. The city disposes of refuse on an open dump where burning is practiced. The primary fuel is coal, although natural gas and oil are used. There are operations in the Athens area which emit objectionable amounts of pollutants to the atmosphere and cause discomfort or inconvenience to residents. Complaints concerning air pollution are received and are concerned with municipal and industrial activities. These problems include the dump, odor from a paper mill (strong, disagreeable) and odor from a producer of rubberized hair which, fortunately, is located in a nonpopulous area. Air pollution problems are considered of minor significance.

There are no air pollution problems apparent in Meigs or Rhea Counties.

In Monroe County there are operations that emit objectionable amounts of pollutants to the atmosphere causing discomfort or inconvenience to residents and concerning which complaints are made. The air pollution problems concern dust from ore processing, creosote odors, dust from crushed rock and limestone companies, odor from renderers, smoke and odor from an open dump, smoke from a lumber mill burning wood wastes, and dust from a feed mill. In general, problems are considered minor. Monroe is largely an agricultural county.

The famous "man-made desert" of the Ducktown area, described previously in this report, is located in Polk County. The only noted air pollution problem in the county is the copper company and concerns fumes and gases (sulfur oxides and nitrogen oxides). These pollutants reportedly are in sufficient quantities to cause damage to property and vegetation and are considered of major significance.

## Maryville--Alcoa

The general topography in the immediate vicinity is gently rolling with a few hills rising about 150 feet located in all directions from these cities. About 3½ miles east of these cities is a ridge about 600 feet high, and 12 miles southeast a mountain chain reaches 1500 to 2000 feet above the city. The Cumberland Mountains are about 40 miles to the northwest. Being in the valley and ridge province, the climatological conditions are such that, on occasion, during certain seasons, particularly in the fall, pollutants are not adequately dispersed (see Knoxville, below).

The city of Maryville is the county seat of Blount County, and Alcoa is immediately adjacent to this city. The combined 1955 population of Maryville and Alcoa was 18,500. Growth expectations for Blount County are high, with an increase of 25 percent anticipated for the period 1955 to 1965.

Industrial employment in Blount County is 9130 (est. 1956), of which 8375 are employed in two primary metal plants. The biggest industry is the aluminum plant. The release of fluorides from the manufacture of aluminum created a major problem several years back. With the installation of collection equipment, this problem has reportedly been brought under control. Some minor emissions of dust, smoke, solvents, acids, carbon and gases are present. These are not reported to be significant. In 1950, 74 percent of the homes were heated by coal. There are some smoke emissions from residences, laundries, etc., but local officials report no objectionable amounts of pollutants are emitted to the atmosphere.

## Knoxville

Located near the middle of the valley and ridge province on the Tennessee River, Knoxville experiences climatological conditions typical of this type terrain. Eight miles southeast of the city a ridge rises 300 to 400 feet above the city elevation and eight miles further another ridge rises 2000 feet. About three miles northwest of the city several small ridges rise 400 to 500 feet. The city is fairly open to the northeast and southwest.

Climatological data (Table 31) reveal that Knoxville has a fairly mild

### TABLE 31

### SELECTED CLIMATOLOGICAL DATA FOR KNOXVILLE[40.16]
### 1949-1954

| MONTH | DEGREE DAYS | PRECIPI-TATION | MEAN HOURLY WIND SPEED (M.P.H.) | PREVAILING WIND DIRECTION | PERCENT CALMS | PERCENT POSSIBLE SUNSHINE | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|---|---|
| JANUARY | 760 | 4.5 | 7.3 | SW | 25 | 42 | 2 |
| FEBRUARY | 650 | 4.9 | 7.7 | NE | 26 | 48 | 1 |
| MARCH | 500 | 4.8 | 8.1 | SW | 22 | 53 | 1 |
| APRIL | 196 | 3.6 | 7.9 | SW | 21 | 59 | - |
| MAY | 50 | 3.6 | 6.7 | SW | 32 | 64 | 1 |
| JUNE | 0 | 3.5 | 6.2 | SW | 30 | 66 | 1 |
| JULY | 0 | 4.7 | 5.9 | SW | 38 | 64 | 1 |
| AUGUST | 0 | 3.4 | 5.6 | NE | 42 | 59 | 2 |
| SEPTEMBER | 33 | 2.5 | 5.6 | NE | 39 | 64 | 2 |
| OCTOBER | 179 | 2.6 | 5.8 | NE | 44 | 64 | 3 |
| NOVEMBER | 498 | 3.1 | 6.5 | NE | 32 | 53 | 2 |
| DECEMBER | 744 | 4.3 | 6.9 | NE | 33 | 41 | 2 |
| YEAR | 3,590 | 45.7 | 6.7 | NE | 32 | 56 | 18 |

heating season, a low mean wind velocity, (particularly in the early fall), a moderate number of days of heavy fog, and prevailing wind directions of northeast and southwest, parallel to the valley axis. Except during stable conditions, pollutants generally escape from this open valley. However, during periods of low level inversions and weak winds, pollutants may accumulate over the city, particularly in the fall when calms and light winds are prevalent.

Population estimates for the Knoxville area indicate a substantial growth (Table 32).

### TABLE 32

### POPULATION FIGURES FOR KNOXVILLE[1.3.5]

| YEAR | HAMILTON COUNTY | CHATTANOOGA | REST OF COUNTY |
|---|---|---|---|
| 1940 | 178,468 | 111,580 | 66,888 |
| 1950 | 223,007 | 124,769 | 98,238 |
| 1955 | 240,181 | 128,040 | 112,141 |
| 1960 | 263,614 | 135,339 | 128,275 |
| 1965 | 286,098 | 141,876 | 144,222 |
| 2000 | 340,000 | - | - |

Of a total nonagricultural employment of 115,850 in the Knoxville metropolitan area (Knox, Blount and Anderson Counties), 44,450 were employed in manufacturing (est. 1957). Knox County accounted for 44 percent of these, or 19,550. Leading industries are food, textiles, apparel, stone, clay and glass, and instruments. More detailed employment data are given in Appendix C. Industrial emissions include fluoride from a fertilizer plant; smoke and odor from an asphalt plant; manganese, sulfite odor, acids and ammonia from an electric furnace operation; dusts from shale, cement and lime companies and monument works; odors from organic vapors, including methyl methacrylate; coal smoke and dust from an aggregate processor, paint spray, the usual fumes and smoke of foundry cupola emissions (uncontrolled), and general smoke from combustion of soft coal.

The major fuel used in this area is coal, and coal smoke has been a major problem. Natural gas has been available for six years and is being used increasingly, especially in industry. Electric heat is popular in new dwelling units. In 1950 coal was used in heating 79 percent of the residential dwelling units. Coal usage in 1956 was estimated at 250,000 tons, all bituminous. The use of coal has been declining. At the start of World War II an estimated 800,000 tons of soft coal were used per year. This decline reflects the use of natural gas both industrially and residentially, the dieselization of the railroads and increased use of electric heat for new homes. Gas usage in Knoxville and area is 2.58 billion cubic feet. Total fuel oil consumption in Knoxville and adjacent area is estimated at 3,600,000 gallons. The consumption of fuel, especially soft coal, is a major source of pollution in Knoxville, although pollution from this source is much less than it was 20 or even 10 years ago. Refuse in Knoxville and Knox County is disposed of in land fills. Some smoke has been reported from back yard burning but this source of pollution is not too prevalent. In 1956, 82,440 motor vehicles registered in the county consumed an estimated 68,500,000 gallons of gasoline. The city is served by 25 common carrier truck lines, 6 Federal highways, and 2 railroads operating 59 trains a day (all diesel).

There are operations in the Knoxville area which emit pollutants to the air in sufficient quantities to cause discomfort or inconvenience to residents and damage to property. Complaints concerning air pollution have been received concerning smoke from laundries and junk auto scrapping, odor from a rendering plant, smoke from open burning, smoke and odor from an asphalt road mix plant, odor from a plastics company, motor bus fumes, and smoke from schools, apartment houses and substandard houses. Generally, air pollution is attributed to domestic, commercial, and industrial activities and is not considered of major significance locally. Coal smoke has been the major problem, and while this problem has been greatly reduced in the past 10 years through a local control program and a marked decrease in coal usage, there still remains a considerable nuisance and economic problem from smoke. No interjurisdictional problems were reported.

There is a local air pollution ordinance and two smoke inspectors. These inspectors have, in addition to their smoke abatement work, responsibility for the inspection of boilers and all new gas-fired installations. These additional duties require most of their time, with the practical result that little is done in the smoke abatement field. The local program has accomplished some improvements in the past. It is inadequate to provide presently needed activity. The city of Knoxville recently joined the U.S. Public Health Service's National Air Sampling Network. Results of eight months of sampling showed that Knoxville had an average particulate loading of 123 micrograms per cubic meter of air; individual values ranged from a low of 68 to a high of 232. Values of particulate loading for Knoxville are quite close to those of other cities of comparable size participating in the National Air Sampling Network. The average concentration of organic material (benzene soluble material) was 10.8 micrograms per cubic meter of air; individual values ranged from a low of 5.2 to a high of 21.3. Some results of dustfall studies made by the smoke inspection bureau are given in Table 33. The program has been discontinued in recent years because of lack of resources. Combustible matter in the settled dust for 1946 to 1950 ran 41 percent for August and 48 percent for February. Dustfall has run from 20 to 80 percent (avg. 50 percent) more in the winter months than in the summer. These data reflect what has been mentioned previously, that the major problem is combustion of fuel and that this problem is considerably better today than in the past, reflecting the use of gas in industry, the increasing use of gas, liquid fuel and electricity for domestic heating, and the conversion of

TABLE 33

DUSTFALL IN KNOXVILLE--24 STATIONS

TONS/SQUARE MILE/YEAR

| YEAR | AUGUST | FEBRUARY | AVERAGE |
|---|---|---|---|
| 1927 | 207 | 314 | 260 |
| 1929 | 236 | 300 | 268 |
| 1930 | 258 | 439 | 349 |
| 1946 | 183 | 293 | 238 |
| 1948 | 128 | 186 | 157 |
| 1949 | 101 | 186 | 143 |
| 1950 | 111 | 136 | 123 |
| 1951 | - | - | 88 |

locomotives from coal to diesel.

Oak Ridge

This area is located in a valley and ridge province. The great valley is about 40 miles wide here and enclosed by mountains of 2500 feet on the west and 5500 feet on the east. The immediate topography consists of parallel ridges cut by many ravines and spaced about one mile apart. These rise 100 to 400 feet above the valley floor. A great amount of information on the climatological aspects of this region is available.[31] Selected climatological data are given in Table 34.

Population estimates for Anderson County show a considerable growth. An increase of 37 percent is anticipated for the period 1955 to 1965. The 1950 population of Oak Ridge was 30,230.

The only industries in Oak Ridge are the Atomic Energy Commission's plants (run by Union Carbide and Carbon Corporation) and Abbot Laboratories. Employment is currently estimated at about 15,000. AEC facilities consist of an electromagnetic separation plant, a gaseous diffusion plant, and the national laboratories. Fuel usage amounted to approximately 540,000 gallons of oil, 18,600 tons of coal, and 289,226,000 cu. ft. of natural gas. Gas has been available for only 1½ years. Residential heating for 1957 was 43 percent, gas; 20 percent, electricity; 19 percent, oil; and 18 percent, coal.

Local problems associated with the AEC plants include fluorine from the diffusion plant, smoke from the plant heating system, and radioactive emissions. The AEC has a system by which all stacks and several areas are monitored. It is reported that there is no radiation hazard in this area. There is a general smoke problem in the city and some ash and sulfur dioxide from the Kingston plant of the TVA. These problems are all reportedly of minor significance.

The remainder of Anderson County is predominantly rural. The industrial employment is 1035 (est. 1956) and the major industry is textiles. Problems indicated include dust from rock crushing, soot and smoke from a textile mill, smoke from laundries, dust from roads, and smoke and odor from dumps. Problems are considered of minor significance. The other two counties in this district health department (Morgan and Scott) are rural counties (total manufacturing employment--670) with no reported problems of air pollution. Current population (est. 1955) is 33,500. The 1965 predicted population is 36,670, up 9.5 percent.

TABLE 34

SELECTED CLIMATOLOGICAL DATA FOR OAKRIDGE[16.40]

1949-1954

| MONTH | DEGREE DAYS | PRECIPITATION | MEAN HOURLY WIND SPEED (M.P.H.) | PREVAILING WIND DIRECTION | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|
| JANUARY | 834 | 6.1 | 4.9 | NE | 2 |
| FEBRUARY | 721 | 6.0 | 4.9 | NE | 1 |
| MARCH | 551 | 5.7 | 5.3 | SW | 1 |
| APRIL | 227 | 4.1 | 5.7 | SW | 1 |
| MAY | 58 | 4.2 | 4.4 | NE | 2 |
| JUNE | 0 | 3.9 | 3.8 | SW | 2 |
| JULY | 0 | 5.3 | 3.7 | NE | 3 |
| AUGUST | 0 | 4.1 | 3.5 | NE | 4 |
| SEPTEMBER | 40 | 2.6 | 3.8 | NE | 2 |
| OCTOBER | 229 | 2.4 | 3.7 | NE | 7 |
| NOVEMBER | 588 | 4.0 | 4.2 | SW | 7 |
| DECEMBER | 812 | 5.7 | 4.5 | NE | 2 |
| YEAR | 4,028 | 53.9 | 4.4 | NE | 34 |

### Morristown

Morristown, with a population (1955) of 14,700, is situated in a shallow valley. A ridge about three miles southeast of the city rises 200 to 300 feet. On the northwest side of the city are some hills rising to 300 feet in elevation. Ten miles northwest of the city are some ridges rising 700 feet. The valley is open to the northeast and southwest. Population statistics indicate a growth of 26 percent for Morristown and 17 percent for all of Hamblen County for the period 1955 to 1965.

Industrial employment in Hamblen County is 4435 (est. 1956), and the larger industries are furniture, chemicals, and textiles. Industrial emissions include carbon disulfide and hydrogen sulfide from a rayon plant, carbon disulfide from a producer of this chemical, dust from a crushed stone plant, and smoke from burning wood wastes from 18 furniture plants. Refuse is disposed of on a dump, but the city is going to change to a land fill operation. There are operations in Morristown that emit objectionable amounts of pollutants to the atmosphere which cause discomfort or inconvenience to residents. Air pollution is attributed to industrial sources, mainly, the furniture works (smoke) but also some odor from the rayon plant (located six miles from the city) and to the municipal dump. These problems are considered of minor significance.

Jefferson and Grainger Counties are also served by this district health department. Jefferson County has a population (1955) of 19,434, and an industrial employment of 760. Grainger County has a population (1955) of 12,814, and an industrial employment of 780. Little growth is anticipated in either county. There were no reported air pollution problems.

### Tri-city Area (Johnson City, Bristol, Kingsport)

The tri-cities, Johnson City, Bristol and Kingsport, are situated in a bowl which is open to the southwest--the beginning of the great valley of east Tennessee. Climatological data from the tri-city (Bristol) airport, located about equidistant from Bristol, Kingsport and Johnson City, are given in Table 35.

The relatively low mean hourly wind speed and the frequent occurrence of calms and heavy fog would indicate that atmospheric conditions, on occasion, would likely be unfavorable to dispersion of pollutants.

TABLE 35

SELECTED CLIMATOLOGICAL DATA FOR TRI-CITIES[46,16]

1949-1954

BRISTOL AIRPORT

| MONTH | DEGREE DAYS | PRECIPITATION | MEAN HOURLY WIND SPEED (M.P.H.) | PREVAILING WIND DIRECTION | PERCENT CALMS | HEAVY FOG (DAYS) |
|---|---|---|---|---|---|---|
| JANUARY | 818 | 3.5 | 6.9 | WSW | 37 | 3 |
| FEBRUARY | 720 | 3.5 | 6.7 | W | 30 | 3 |
| MARCH | 576 | 3.8 | 7.9 | W | 29 | 1 |
| APRIL | 274 | 3.2 | 7.8 | WSW | 31 | 2 |
| MAY | 95 | 3.4 | 5.0 | WSW | 42 | 3 |
| JUNE | 0 | 3.7 | 4.5 | W | 43 | 4 |
| JULY | 0 | 5.1 | 4.1 | NE | 50 | 4 |
| AUGUST | 0 | 3.9 | 3.9 | NE | 49 | 7 |
| SEPTEMBER | 58 | 2.8 | 4.6 | NE | 52 | 5 |
| OCTOBER | 239 | 2.4 | 4.7 | E | 49 | 4 |
| NOVEMBER | 576 | 2.6 | 6.5 | E | 47 | 2 |
| DECEMBER | 815 | 43.4 | 6.1 | E | 45 | 3 |
| YEAR | 4,148 | 41.4 | 5.7 | W | 42 | 41 |

*Johnson City:* Johnson City, with a population of 27,920, is set in a bowl, ringed by hills and ridges. These elevations rise 200 to 1300 feet above the city elevation, being higher southeast of town and lower northwest. These heights are about four miles from town. The climatology of this area would, on occasion, favor the accumulation of pollutants over the city.

Population expectations are for a moderate growth of 7 percent for Johnson City between 1955 and 1965. For Washington County, a growth of 12 percent is expected.

Johnson City is less directly dependent on manufacturing industries than the other two urban communities of the tri-cities area. It is more closely allied to its agricultural hinterland. In Washington County there were 3590 manufacturing employees (est. 1956). In 1950, there were 3420 agricultural employees. Principal industries are lumber, furniture and tobacco--industries directly dependent on materials produced in the region. Industrial emissions include smoke from burning wood wastes at lumber and furniture plants, mica dust, dust from a brick works, and some foundry emissions. Fuel usage for Johnson City and area for 1956 was estimated at 740 million cubic feet of natural gas, 1.5 million gallons of oil, and 50 to 60,000 tons of coal. There is a smoke problem from the combustion of fuel, particularly wood wastes and soft coal. Refuse is disposed of in a land fill, and residential back yard burning is limited. There were 22,984 motor vehicles registered in Washington County in 1956; gasoline consumption is estimated at 19 million gallons per year. Motor vehicle emissions are apparently no problem.

There are operations in Johnson City which emit objectionable amounts of pollutants in sufficient concentrations to cause inconvenience or discomfort to residents and limited damage to vegetation. Complaints have been received concerning air pollution. These complaints have concerned smoke from flooring concerns, a lumber mill and a laundry; dust from a mica plant; dust from a brick company; odors from a dairy; and several miscellaneous smoke sources. In general, air pollution is attributed to commercial and industrial sources and is considered of minor significance. No extrajurisdictional air pollution problems were noted. There are no regulations for the control of air pollution.

*Sullivan County:* Sullivan County contains two major cities, Kingsport and Bristol. It is the fifth largest manufacturing center in the State (only the four metropolitan areas are larger) and has excellent growth prospects (Table 36).

TABLE 36

POPULATION TRENDS FOR SULLIVAN COUNTY[1.3.5]

| YEAR | SULLIVAN COUNTY | KINGSPORT | BRISTOL(a) | REST OF COUNTY |
|---|---|---|---|---|
| 1940 | 69,085 | 14,404 | 14,004 | 40,677 |
| 1950 | 95,063 | 19,571 | 16,771 | 58,721 |
| 1955 | 108,148 | 22,062 | 17,552 | 68,534 |
| 1960 | 123,747 | 25,046 | 18,859 | 79,842 |
| 1965 | 138,868 | 27,885 | 20,011 | 90,972 |

(a) Bristol, Tennessee only.

There are 17,300 manufacturing employees in Sullivan County (est. 1956). The larger industries are chemicals (which accounts for 45 percent of all employees), ordnance, textiles, apparel, paper, printing, and stone, clay and glass. Noted industrial emissions include organic material and acetates; dust from a brick plant, a cement plant and a glass works; aldehydes; sulfites, ash, sulfur dioxide, wood dust, tannic acid and odor from a paper mill; and chromic acid and odor from a printing establishment. There are 40,613 motor vehicles registered in the county (1956) which consume an estimated 33,800,000 gallons of gasoline. There is no apparent problem from this source. For the county as a whole, objectionable amounts of pollutants are emitted from domestic and industrial sources. These pollutants cause discomfort or inconvenience to residents and damage to property. In general, the problems are considered minor.

*Kingsport:* Kingsport is situated

in a bowl, ringed by hills and ridges rising 200 to 1000 feet above the city, presenting conditions for intensification of air pollution problems.

Kingsport accounts for 20 percent of the county's population (Table 36) and 75 percent of its manufacturing employment. Leading industries are chemicals, printing and textiles. The largest single industrial unit in the State is located here. Industrial employment (1956) is 14,365. Industrial emissions constituted a major problem a few years back, but, reportedly, the major offenders have been largely corrected. The plants were a cement plant, which changed from a dry to a wet process and installed collection equipment, a paper company, which has installed control equipment claimed to be 95 percent efficient (for dust control), and a brick company, which changed from coal to gas for its fuel for the kilns. Fuel consumption estimates are given in Table 37.

In 1950 coal was used to heat 70 percent and oil 23 percent of residences. This was before the availability of natural gas. Since Kingsport is not served by the TVA system, electric heat is not as popular as in other urban areas of the State. Refuse is disposed of in a land fill, and there is little or no back yard incineration of rubbish. Kingsport is served by one railroad (diesel locomotives), nine motor freight lines, and seven bus lines. There were 15,721 passenger cars registered in the city in 1956. Pollution from transportation facilities is not considered significant.

As mentioned previously, several major sources of air pollution have been corrected or ameliorated. There remain some problems: odor and organic material from a chemical plant, dust from several industrial sources and unpaved parking lots, aldehydes, and odor from a paper mill. The problem of general smoke from combustion of coal has been lessening in recent years, but still constitutes a problem. The air pollution problems are considered of minor significance. No extrajurisdictional pollution sources were reported.

Kingsport has an ordinance to control air pollution. The air pollution program of the city did much to improve the air quality of Kingsport. Since the recent resignation of the air pollution control director, the program has fallen to the building inspector in addition to his regular duties. Kingsport has done some air sampling but discontinued their program in 1953. Data were unavailable at the time of the survey.

*Bristol:* Bristol is located in a shallow bowl, with surrounding hills and ridges rising 100 to 300 feet above the city. With the occurrence of low level (nocturnal) inversions, pollutants tend to remain over the city.

Bristol is an unusual city in that it straddles the Tennessee-Virginia State line. As such, it presents two politically distinct cities in one geographic

TABLE 37

CURRENT ANNUAL FUEL CONSUMPTION FOR KINGSPORT

| FUEL | AMOUNT |
|---|---|
| GAS | 146.574.000 CU. FT. (a) |
| COAL | 780,000 TONS (b) |
| OIL | 4,300,000 BBLS. |

(a) Does not include large industrial users who buy direct from the main pipe line. Gas has been available for only 2½ years. Of the amount above, 25 per cent was used residentially.

(b) Industrial use is 730,000 tons, residential use is 45,000 tons, and commercial use 5000 tons.

city. Of the total 1950 population of 32,725, about half (16,771) resided in Tennessee. Projected population for 1965 is 39,200, of which 20,010 will reside in Tennessee and 19,190 in Virginia. Of a total manufacturing labor force of 6495, 3930 worked in Tennessee and 2564 in Virginia. Thus, the two cities are about equal.

The major fuel used is coal. In 1950, coal heated 86 percent, oil 4 percent, electricity 6 percent, and other fuel 4 percent of the residences in Bristol, Tennessee. Smoke from soft coal consumption has been Bristol's major problem. Refuse is disposed of in a land fill. Bristol, Tennessee, is served by one railroad which uses diesel locomotives, while Bristol, Virginia, is served by another which uses coal-fired locomotives.

The Chamber of Commerce, a single organization serving both cities, has been very active in the smoke abatement field and has been carrying on a voluntary abatement program. This has been largely a matter of educating firemen and instilling civic pride. The Chamber has had personnel from the Coal Producers' Committee for Smoke Abatement make a survey of industrial, commercial, public and church boiler plants and firing procedures and make recommendations for reducing smoke emission. It is believed that this work did much good. Cooperation from local parties was good, with 95 of the 99 plants inspected meeting the recommendations. However, there still remains a considerable problem.

### Elizabethton

Elizabethton, with a 1955 population of 11,530, is located about nine miles east of Johnson City and the two are frequently called "the twin cities." It is located on the Watauga River. North and west of the city are hills rising 300 to 500 feet above city elevations, while south and east are mountains attaining heights of 500 to 2000 feet above the city. Here again, the topography tends to intensify air pollution problems.

Population estimates indicate a substantial growth for this area of 16 percent for Carter County from 1955 to 1965 and 18 percent for the city.

Industrial employment for Carter County is 4880 (est. 1956) and the major industry is chemicals. Two plants producing rayon account for 86 percent of all manufacturing employees. Industrial emissions include carbon disulfide, hydrogen sulfide, ammonium polysulfide (odors), and dust from a cinder block company and a quarry. The fuel used is primarily coal. Refuse is disposed of in a land fill. Trains are dieselized. No extrajurisdictional sources of pollution were noted.

There are operations in the Elizabethton area which emit objectionable amounts of pollutants to the atmosphere causing discomfort or inconvenience to residents and damage to property. These pollutants are attributed to industrial activities and concern odor and tarnishing of silver from hydrogen sulfide emissions and the dust sources noted. These problems are adjudged locally as unpleasant but of minor significance.

Johnson and Unicoi Counties are served by the same district health department as Carter County. In 1955, Johnson County had a population of 11,700 and Unicoi had 16,315.

Johnson County is entirely rural with no pollution problems.

Unicoi County has some pollution emissions from industrial sources: mica dust from several sources, and dust from other stone, clay and glass plants. These are localized problems and are not considered of major importance.

### Rest of Region V

There remains in this region 10 counties covered by 10 health departments. These counties had a 1955 population of 250,765. The 1950 population was 249,700; the projected 1965 population is 271,455. The 1956 manufacturing employment was 11,954.

Although primarily a group of rural counties, there are food, textile, apparel, printing, chemicals, metals and machinery industries. Industrial emissions include smoke from a lumber company, odor from renderers, dust from quarrying, blast furnace emissions, foundry emissions, powdered metals, ferromanganese, smoke, paint spray, odor from tobacco warehouses, odor from a fertilizer plant, and dust from a crushed stone plant.

Of these 10 counties, five reported objectionable amounts of pollutants, four reported discomfort or inconvenience to residents, and two reported damage to property. Two counties indicated they received complaints of air pollution, three reported problems due to municipal activities, one to domestic activities, and four to industrial activities. One considered its pollution problem to be of major significance, and three reported some local activity to control air pollution.

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# APPENDIX A

# SURVEY FORMS

R. H. HUTCHESON, M. D.
COMMISSIONER OF PUBLIC HEALTH

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH
NASHVILLE 3

PUBLIC HEALTH COUNCIL
OREN A. OLIVER, D.D.S., CHAIRMAN, NASHVILLE
J. R. THOMPSON, JR., M.D., VICE-CHAIRMAN, JACKSON
WILLIAM P. WINTER, PH. C., SECRETARY, NASHVILLE
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T. R. RAY, M.D., SHELBYVILLE
MRS. RALPH W. FROST, KNOXVILLE
M. T. TIPTON, M.D., UNION CITY
JOHN W. ADAMS, JR., M.D., CHATTANOOGA

The Tennessee Department of Public Health has undertaken an appraisal of the present and future potential Air Pollution problems of the State. In this connection, the U. S. Public Health Service is co-operating with this Department in the conduct of the appraisal.

The objective of this study will be to investigate the status of Air Pollution in Tennessee, and to supply, insofar as possible, data for determining the need and scope of future Air Pollution Control Program activities on a State or local basis. This appraisal will involve a study of population trends, geography and topography, meteorology and climatology, fuel usage, and major sources of Air Pollution.

Your knowledge and information concerning your area will be of material assistance to the appraisal, as a means of providing certain guide lines for its conduct. In this connection, we would appreciate your completing, on the basis of information available to you, the enclosed "Air Pollution Appraisal Questionnaire."

Your interest and co-operation in this matter is sincerely appreciated.

Very truly yours,

RHHutcheson

R. H. Hutcheson, M.D.
Commissioner

RHH/PAK/lm

STATE OF TENNESSEE
DEPARTMENT OF PUBLIC HEALTH

## AIR POLLUTION APPRAISAL QUESTIONNAIRE

| | YES | NO |
|---|---|---|
| 1. Are there any operations (municipal, domestic, industrial) in your area of jurisdiction that emit objectionable amounts of smoke, fumes, dust or odor to the atmosphere? | ( ) | ( ) |
| 2. In your opinion are these pollutants present in sufficient concentrations to cause: | | |
| a. Discomfort or inconvenience to residents? | ( ) | ( ) |
| b. Damage to property? (autos, paint, clothing, buildings, etc.) | ( ) | ( ) |
| c. Damage to vegetation? | ( ) | ( ) |
| d. Injury to animal life? | ( ) | ( ) |
| 3. Has your office received complaints concerning air pollution during the past two years? | ( ) | ( ) |
| 4. Are the air pollution problems in your area of jurisdiction principally due to: | | |
| a. Municipal activities (dumps, incinerators, etc.) | ( ) | ( ) |
| b. Domestic activities (incinerators, heating plants, etc.) | ( ) | ( ) |
| c. Commercial activities? | ( ) | ( ) |
| d. Industrial activities? | ( ) | ( ) |

5. Please describe briefly any air pollution problems in your area of jurisdiction.

6. In your opinion is the problem described above of major ( ) or of minor ( ) significance?

| | | |
|---|---|---|
| 7. Are there any local ordinances or regulations for the control of smoke, fumes, dust or odor? | ( ) | ( ) |
| 8. Have any steps been taken in your area of jurisdiction to control sources of air pollution? | ( ) | ( ) |
| 9. Are there sources of air pollution outside of your area of jurisdiction which have created a problem in your area? | ( ) | ( ) |

10. Please list any other groups (official or unofficial) in your area of jurisdiction who might furnish additional information regarding air pollution problems.

Return to:

Industrial Hygiene Service,
Tennessee Department of Public Health
Nashville, Tennessee

County:

Signed:

# APPENDIX B

# EXAMPLES OF POLLUTION EMISSION RATES

# APPENDIX B
# EXAMPLES OF POLLUTION EMISSION RATES

## NOTE

The data presented in this appendix are of value only as general information on the composition and magnitude of pollution from the several activities. They should not be applied to any specific situation without due consideration of the many factors which affect pollution emissions.

### FUEL GAS AND OIL[18]

| COMPONENT | MEASURED AS: | POUNDS OF POLLUTANTS PER 1000 POUNDS OF MATERIAL BURNED | |
|---|---|---|---|
| | | GAS(a) | OIL(b) |
| ALDEHYDES | CHO | 1.0 | 1.3 |
| NITROGEN OXIDES | $NO_2$ | 6.9 | 13.5 |
| SULFUR OXIDES | $SO_2$ | • | 30.0 |
| ACIDS | ACETIC | 1.3 | 13.5 |
| ORGANICS | • | 1.4 | 4.6 |

(a) 1000 lbs. of gas is equivalent to approximately 21,785 cubic feet.

(b) 1000 lbs. of No. 2 fuel oil is equivalent to approximately 140 gallons.

### COAL

| COMPONENT | MEASURED AS: | POUNDS EMITTED PER TON OF COAL BURNED |
|---|---|---|
| SOLIDS | • | 200 |
| SULFUR OXIDES | $SO_2$ | 40 |
| NITROGEN OXIDES | $NO_2$ | 8 |
| ORGANICS | • | 20 |
| ACIDS | ACETIC | 30 |

### AUTOMOBILE ENGINES [18,48]

| COMPONENT | MEASURED AS: | POUNDS EMITTED PER 1000 POUNDS OF GASOLINE | |
|---|---|---|---|
| ALDEHYDE | CHO | 2.8 | 3.0 |
| AMMONIA | $NH_3$ | 0.3 | 0.3 |
| NITROGEN OXIDES | $NO_2$ | 12.3 | 4.0 |
| SULFUR OXIDES | $SO_2$ | 2.8 | 2.8 |
| ACID | ACETIC | 0.3 | 0.3 |
| ORGANICS | • | 70.7 | 30.0 |
| SOLIDS | CARBON | • | 0.05 |
| REFERENCE SOURCE | | 18 | 48 |

### DIESEL ENGINES[49]

| COMPONENT | MEASURED AS: | POUNDS EMITTED PER 1000 LBS. OF DIESEL FUEL BURNED |
|---|---|---|
| PARTICULATES | • | 17 |
| NITROGEN OXIDES | $NO_2$ | 24.5 |
| SULFUR OXIDES | $SO_2$ | 5 |
| LOWER ALDEHYDES | FORMALDEHYDE | 2.5 |
| ORGANIC ACIDS | ACETIC | 5 |

GASOLINE HANDLING LOSSES[47]

10,400 pounds loss per 100,000 gallons of gasoline handled including evaporation losses from marketing, filling service station tanks, filling automobile tanks, and automobile carburetors.

HOUSEHOLD INCINERATORS [18]

| COMPONENT | MEASURED AS: | POUNDS EMITTED PER 100 LBS. OF MATERIAL BURNED |
|---|---|---|
| ALDEHYDE | CHO | 1.8 |
| AMMONIA | $NH_3$ | 0.8 |
| NITROGEN OXIDES | $NO_2$ | 0.2 |
| SULFUR OXIDES | $SO_2$ | 0.4 |
| ACIDS | ACETIC | 0.4 |
| ORGANICS | • | 81.8 |

MUNICIPAL INCINERATORS [50]

| COMPONENT | MEASURED AS: | POUNDS EMITTED PER 100 LBS. OF MATERIAL BURNED |
|---|---|---|
| ORGANICS | • | 0.06 |
| ALDEHYDES | FORMALDEHYDE | 0.07 |
| ACIDS | ACETIC | 0.03 |
| SULFUR OXIDES | $SO_2$ | 0.1 |
| NITROGEN OXIDES | $NO_2$ | 0.1 |
| AMMONIA | $NH_3$ | 0.02 |
| SOLIDS | • | 1.2 |

# APPENDIX C

# EMPLOYMENT STATISTICS

## ESTIMATED NONAGRICULTURAL EMPLOYMENT FOR DECEMBER, 1956[51]

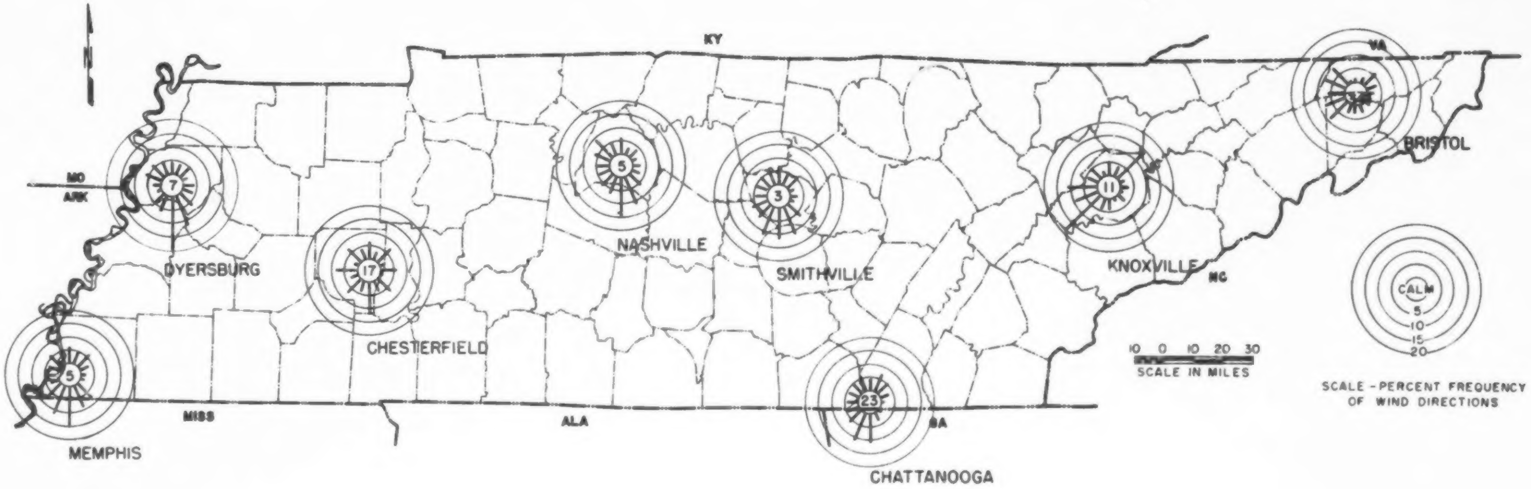
| INDUSTRY | NUMBER OF PLANTS | TENNESSEE | MEMPHIS | NASHVILLE | CHATTANOOGA | KNOXVILLE | TRI-CITIES[(a)] |
|---|---|---|---|---|---|---|---|
| I. TOTAL • |  | 873,700 | 191,400 | 135,600 | 93,200 | 120,050 | 67,800 |
| II. MANUFACTURING |  | 291,100 | 45,800 | 37,800 | 43,750 | 43,600 | 32,820 |
| TEXTILES | 173 | 33,200 | 1,100 | 2,800 | 11,350 | 4,650 | 3,450 |
| CHEMICALS | 267 | 47,000 | 4,150 | 5,400 | 4,800 |  | 13,600 |
| FOOD PRODUCTS | 772 | 27,200 | 7,150 | 5,100 | 2,700 | 3,250 | 1,600 |
| APPAREL | 215 | 33,600 | 1,800 | 2,200 | 1,200 | 3,700 | 2,300 |
| LEATHER | 73 | 13,000 |  | 3,150 |  |  |  |
| PRINTING AND PUBLISHING | 449 | 13,900 |  | 6,000 | 950 | 1,200 | 2,250 |
| RUBBER | 23 | 5,100 |  |  |  |  |  |
| PAPER | 56 | 9,100 | 3,600 |  | 1,800 |  | 1,610 |
| TOBACCO | 12 | 1,300 |  |  |  |  |  |
| PETROLEUM & COAL PRODUCTS | 24 | 700 |  |  |  |  |  |
| LUMBER | 591 | 21,300 | 6,000 | 900 | 1,300 | 900 | 1,240 |
| PRIMARY METALS | 85 | 16,000 |  |  | 4,000 |  | 380 |
| FABRICATED METALS | 267 | 18,100 | 1,800 | 3,000 | 7,400 |  |  |
| FURNITURE AND FIXTURES | 240 | 11,000 | 3,100 | 1,100 | 1,200 | 400 | 930 |
| STONE, CLAY AND GLASS | 283 | 9,300 |  | 1,000 | 2,800 | 1,600 | 1,910 |
| MACHINERY | 195 | 9,500 | 3,750 |  | 2,550 | 1,050 |  |
| TRANSPORTATION EQUIPMENT | 56 | 3,800 |  |  |  |  |  |
| ELECTRICAL MACHINERY | 54 | 7,700 |  |  |  |  |  |
| ORDNANCE & INSTRUMENTS | 35 | 5,700 |  |  |  |  |  |
| ALL OTHERS | 198 | 4,600 | 13,350 | 7,150 | 1,700 | 26,800 | 3,550 |
| III. NON-MANUFACTURING |  | 582,600 | 145,600 | 97,800 | 49,450 | 76,450 | 34,980 |
| WHOLESALE TRADE |  | 56,100 | 17,600 | 9,400 | 4,500 | 6,500 | 2,950 |
| RETAIL TRADE |  | 158,500 | 41,750 | 24,200 | 14,000 | 21,950 | 10,800 |
| GOVERNMENT |  | 137,500 | 28,700 | 15,500 | 8,650 | 16,650 | 4,100 |
| SERVICE |  | 92,300 | 24,250 | 19,400 | 9,000 | 11,450 | 6,450 |
| TRANSPORTATION, COMMUNICATION, AND PUBLIC UTILITIES |  | 59,600 | 16,800 | 12,900 | 5,600 | 7,650 | 3,850 |
| CONSTRUCTION |  | 41,100 | 8,150 | 7,500 | 3,350 | 7,300 | 4,600 |
| FINANCE, INSURANCE & REAL ESTATE |  | 28,900 | 8,100 | 8,600 | 4,250 | 2,700 | 2,000 |
| MINING |  | 8,600 | 250 | 300 | 100 | 2,250 | 230 |

(a) Bristol, Kingsport, Johnson City

# APPENDIX D

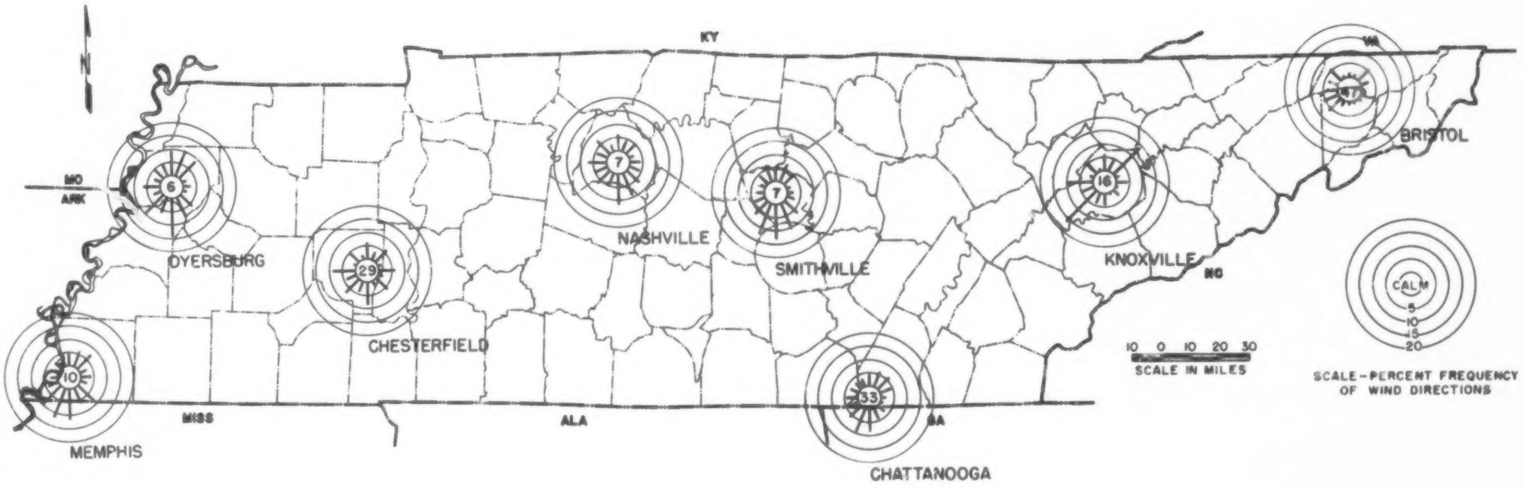
# WIND ROSES

## (31,40,46,52,53)


KY
VA
MO
ARK
MISS
ALA
GA
NC
DYERSBURG
7
MEMPHIS
5
CHESTERFIELD
17
NASHVILLE
5
SMITHVILLE
3
CHATTANOOGA
23
KNOXVILLE
11
BRISTOL
10 0 10 20 30
SCALE IN MILES
CALM
5
10
15
20
SCALE - PERCENT FREQUENCY
OF WIND DIRECTIONS

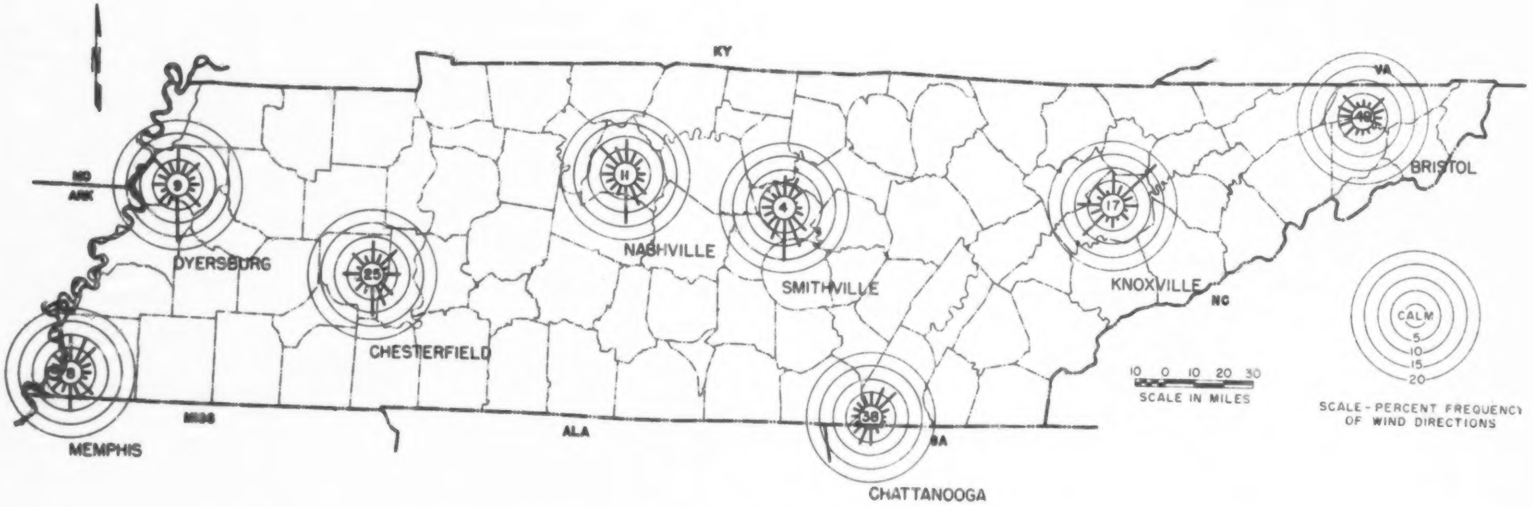
WIND ROSES — SPRING SEASON (MARCH–MAY)

FIGURE 11


KY
VA
MO
ARK
N
MISS
ALA
GA
NC
6
OYERSBURG
10
MEMPHIS
29
CHESTERFIELD
7
NASHVILLE
7
SMITHVILLE
33
CHATTANOOGA
16
KNOXVILLE
17
BRISTOL
10 0 10 20 30
SCALE IN MILES
CALM
5
10
15
20
SCALE-PERCENT FREQUENCY OF WIND DIRECTIONS

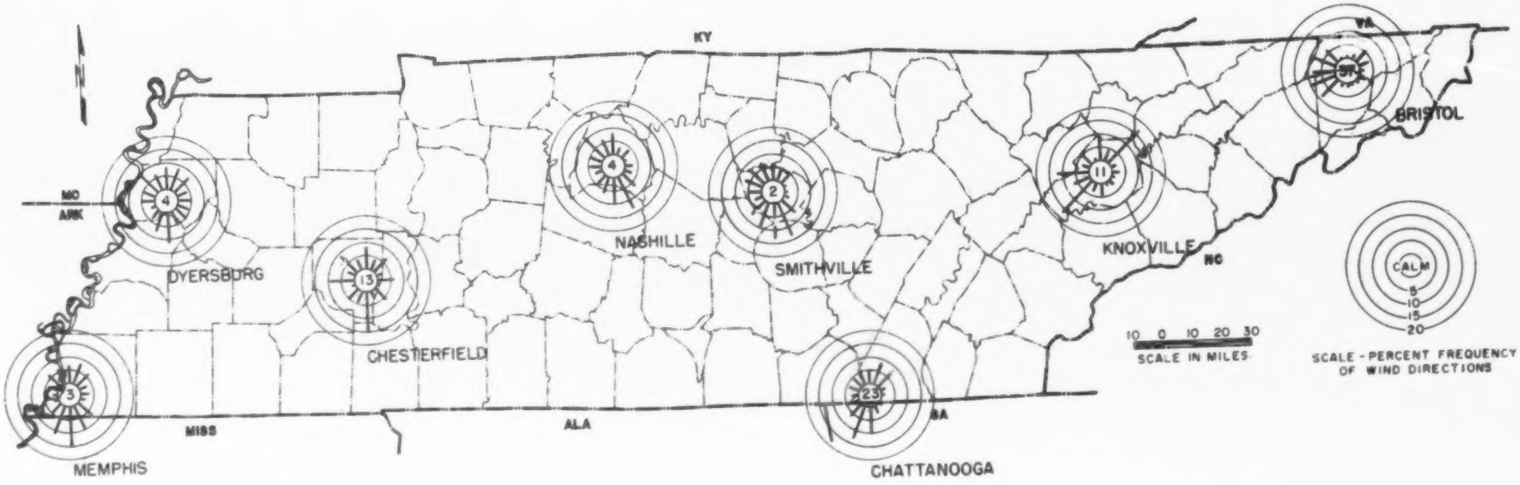
WIND ROSES — SUMMER SEASON (JUNE—AUGUST)

FIGURE 12


KY
MO
ARK
9
DYERSBURG
25
CHESTERFIELD
MEMPHIS
MISS
ALA
11
NASHVILLE
4
SMITHVILLE
38
CHATTANOOGA
GA
17
KNOXVILLE
NC
VA
BRISTOL
10 0 10 20 30
SCALE IN MILES
CALM
5
10
15
20
SCALE - PERCENT FREQUENCY OF WIND DIRECTIONS

WIND ROSES — FALL SEASON (SEPTEMBER — NOVEMBER)

FIGURE 13


KY
VA
BRISTOL
MO
ARK
DYERSBURG
4
13
CHESTERFIELD
4
NASHILLE
2
SMITHVILLE
11
KNOXVILLE
NC
3
MEMPHIS
MISS
ALA
23
GA
CHATTANOOGA
10 0 10 20 30
SCALE IN MILES
CALM
5
10
15
20
SCALE - PERCENT FREQUENCY OF WIND DIRECTIONS

WIND ROSES — WINTER SEASON (DECEMBER — FEBRUARY)

FIGURE 14